THE

ELECTRICAL REVIEW.

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CONTENTS:

	PAGE
The Lightning Express	293
Rules and Regulations for Electric Lighting Steamships.—III.	296
Heilmann Locomotive from an Electrical Point of View ...	296
Arc Lighting.—XIV. (*illustrated*)	297
Relative Economy of Copper in Single-Phase, Two-Phase, and Three-Phase Transmission (*illustrated*)	299
Newspaper Science	300
Another Early Transformer with Closed Magnetic Circuit (*illus.*)	301
A New Electro-Dynamometer	302
Electricity Supply Stations.—Scarborough Electricity Supply Company's Works (*illustrated*)	303
Competition *v.* Fairness	305
Correspondence:—The Theryc-Oblasser Accumulator	305
Balancing in a Three-Wire Station with only One Machine Running (*illustrated*)...	307
Synchronising Alternators.—The Heilmann Locomotive ...	307
Electric Lighting of Steamships	308
Legal:—Muirhead *v.* Commercial Cable Company (*continued*) ...	309
Edison-Bell Phonograph Corporation *v.* The London Phonograph Company	311
W. Selfer *v.* City of London Electric Lighting Company ...	311
Hall *v.* Charlesworth.—Wayleaves	312
Wise *v.* Metropolitan Electric Supply Company	312
Books Received	312
Business Notices	313
Contracts Open and Closed	314
Notes	314
City Notes, &c.	317
Traffic Receipts	318
Share List of Electrical Companies	319
Proceedings of Societies:—	
The Institution of Electrical Engineers (*illustrated*) ...	320
Physical Society...	322
Notes on Designing a System of Underground Electric Light Mains	322
New Patents	324
Abstracts of Published Specifications	324

THE

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THE LIGHTNING EXPRESS.

SEVRAEL months ago the extravagant scheme of a Lightning Express was put forward by Mr. Behr, who sent us a long letter in which he talked much about his scheme, but told us very little of it. Mr. Behr now blossoms forth in an interview with a *Pall Mall Gazette* reporter. Considering that Mr. Behr proposes to revolutionise our railway speeds, we should have thought he might have aspired to shine in something different from an ordinary newspaper, and, we fear, that the recrudescence of the scheme in this direction must be taken somewhat as an index of its value. So many devices struggle fitfully into existence and afterwards grow in stature, that it does not always suffice to write down the bantlings as failures. Let us quietly examine a few of the points in Mr. Behr's idea to see if there be much good in it. Calling up to recollection some of the inventions destined to revolutionise everything hitherto existing—we are always a trifle sceptical of those revolutionaries—we see pass before our mental vision the man with the new steam locomotive. That locomotive was not wanted, and is no more. Then that patent furnace—re-hash of an old patent ghouled out of a forgotten book, was to confer unlimited blessings on mankind; yet, out of a capital of £200,000, not one successful furnace was ever made. What of Elmore? What of scores of other highly belauded schemes? The only scheme at present known to the writer that is likely to effect a revolution of the trade or art of which it forms a part, is a simple machine, the invention of a practical man in the business, but no notice of this will appear in the *Pall Mall*, or any other journal, and those most interested are saying least about it. The public are never asked to the feast when it is a real feast. Feast days are kept by the men in the swim; the public keep the fast days. In addition to abusing existing arrangements, most revolutionary schemers have a pet text which serves many turns. We remember a patent valve gear which was run on a text for a long time, until finally two of the engineers who had done most to forward the gear, determined to have a full size diagram of the movement. They worked late at nights, and to fine measurements, and found something, but it was not what they sought. The text had no basis in fact, and, soon after, both those men accepted other offers. Mr. Behr's text is centrifugal force. This, he claims, is such that an ordinary railway cannot be safe at high speeds, owing to the tendency to overturn. There is, we may add, absolutely no overturning tendency if the super-elevation of the outer rail is suited to the speed; the danger is in not running fast enough for the super-elevation.

Now, in the single rail or Lartigue system, which it is intended to employ for the Lightning Express at 150 miles per hour, there are two possible methods of suspending the carriages so as to overcome the fearful effects of centrifugal

force in rounding curves. One, and we should infer not the one to be employed, is to so place the load, that the centre of gravity will be brought well below the point of suspension. So suspended, and with a rail, the surface of which is such as to fit the wheel at any angle, the underhung body of the carriage will fly outwards as it passes curves; but if the rails are wedge-shaped, there will be just as much reason to give them an angular cant, as there is to give a super-elevation of the outer rail of an ordinary track, and, moreover, the speed will have to be kept equal to the rail angle, or the wheels will not fit. True, the lateral guide wheels will maintain the carriage at the angle of the rail cant, but of this more anon.

If, however, we are to accept the *Pall Mall* as accurate, the centre of gravity is to be maintained at the rail level, or, as stated, "as low as the point of support." We begin now to see some reason for the high speed. A trifle under three hours to Edinburgh can, perhaps, be endured without dinner. There will then be no need for a dining car, for if there were, and the centre of gravity being at the rail level, the train ran round a curve upon an even keel, if we may use a nautical phrase, what about the soup? Soup, though on board a train it may only be arrowroot gruel with a dash of beef essence, behaves as water, and follows strictly the laws governing the movements of fluid bodies, and one such law is that the surface of a fluid is a plane normal to the resultant pressure, and this finally means that the soup will fly out at the windows on the outer side of the curve. But perhaps this is of no account, for the passengers at 150 miles an hour will either be thrown flat against the outer side of the carriage, which does not change from its vertical, or if there be a longitudinal bar in the carriage at the rail level, passengers will have the option of hanging themselves over this bar, and, being bent double across their centres of gravity when taking curves. We may seem to joke. We are not doing so; it is absolutely essential for passenger traffic that the resultant of gravity and centrifugal force be a normal to the surface of the seats. True, the passengers might avoid the above cross-breaking stresses by lying down, or they might be packed in so many swing trays, room being allowed for these to swing freely.

We can scarcely believe it to be the intention to balance the carriages at the rail level against angular swing. And there's the rub again. If the centre of gravity be hung in the trough below the rail, and guide wheels be employed to compel the carriages to maintain the angle proper to the rail cant, then, unless the speed be maintained equal to the cant, the passengers will fall inwards at curves, and be no better off than on an ordinary railroad. Given, however, a rail that will suit any and every angle of suspension and speed, all would be well, but there would be considerable practical difficulties in supporting the girder rail, and the gap between the two halves of the train would require to be enormous, wide enough to allow the carriages to swing to the full measure of what we may term the super-elevation, without striking the supporting posts, and these must either be parallel with the angle of swing to act as struts, or very stiff to act as vertical cantilevers.

The more we look at this scheme, the less does it appear practicable. Can it be that Mr. Behr has thought out the mechanics of the train and forgotten the passengers. There is absolutely no value in the fact that the French Government have approved of a Lartigue railway for a local line. Why are we not told the speed that is to be attained thereon? Says the *Pall Mall* of Mr. Hills, of the Thames Ironworks, who have the scheme in hand: "It says much for his belief in it," that he has made a proposal to the directors of the South-Eastern and South-Western Railways for a line between Cannon Street and Charing Cross, *via* Waterloo. We agree to this; it does say very much, but in the direction opposite to what our contemporary intends to convey. Fancy a trial on a couple of miles of railway of an ambitious 150 miles per hour machine, which Mr. Grove, the electrician of the Thames Ironworks, is confident will run us to Brighton in 20 minutes. And to the South-Eastern directors of all people! A body of men who could not see a train run at 60 miles an hour and live; it would send them off their little minds straightway. South-Eastern! Why not give the Chatham a show also? "Naturally," says Mr. Grove, "I cannot tell you all we are doing"; "it would be to tell our rivals." This is the usual story—rivals peeping round to pick up scraps of knowledge. What nonsense this is! but worse follows. They "cannot buy electric motors to do their work, under the conditions of weight and size," and so they will "devise and make" their motors. Have the Thames Ironworks suddenly discovered an entirely new set of behaviour rules for electricity that they are to build motors of a given power, with less weight of iron and copper than anyone else?

Not content with this, they have devised a perfectly safe system of distributing their high pressure electricity, and the conductor is to be enclosed in an air-tight box—but why should we go through all this twaddle. The pity is that the lay public is taken by the high sounding terms and the claims of a *genius* to having found out something no one has ever thought of before.

What do figures show? A railway curve of half a mile radius is a very easy curve. Curves of 500 feet are common enough. At 150 miles per hour a suspended car will hang just about 30° from the vertical when going round a curve of half a mile radius, unless we have made a slip in our figures, and the lateral pull upon the posts supporting the rail will be very nearly six-tenths of gravity. That fools step in where angels fear to tread has never received fuller exemplification than in the parasitic schemes that have been harnessed upon the science of electricity, and we are much mistaken if Mr. Behr's line will not come into a very similar category. If ever to be a success, it will be found necessary to use expensive lines, nearly straight from point to point, or to employ automatic means to shut off current and apply brakes at curves, all of which will require to have an easement at their junctions with the tangents. But what is to be particularly deprecated in all these extravagant schemes is the confusion of issues put before the public. They are asked to travel 150 miles per hour, when the time arrives the trial is made at probably 15 miles speed, the public of course not being so rude as to demand a higher speed out of respect to Sir Edward Watkin. When all is over they go away believing the highest speed to be possible, and to have been practically demonstrated, and, after all, the only facts demonstrated are the practicability of the Lartigue system at low speeds, and the power of an electric armature to turn an axle. Really these re-demonstrations of recognised facts are a little wearisome.

Electricity and Coast Defence.

In a recent issue we called attention to the possibilities awaiting the application of electricity to the art of war, and especially to the use of the electric light as an adjunct to coast defence. It is satisfactory to notice that the leading exponents of the cult of Mars are awakening to the importance of this, which we have always advocated. Colonel J. R. J. Jocelyn, R.A., very wisely remarked the other evening at the Royal United Service Institution, in the course of a lecture on some aspects of coast defence, that the arrangements for illuminating channels, harbours, &c., should not be left to be settled under the pressure of imminent war. Artillery experts cannot be expected to be experts in electric lighting. They may state their needs, but it remains for the practical electrical engineer to design and execute the necessary arrangements. Something would be gained if leading electrical engineers would come forward and read papers on the subject: it would, at least, be a means of exciting attention and discussion. The present uncertainty under which those who are primarily responsible for the guardianship of our coasts, is a serious embarassment to the preparation of practical schemes of defence. Meanwhile, the French navy is being steadily equipped with various kinds of electrical apparatus, designed to make the ships more accurate fighting machines. Three French cruisers have recently been installed with the turret electric mountings, invented by Canet. Not only are the turrets swung, but the guns are directed and loaded by means of electric gear. Greater ease and speed of working are thus attained. The American men-of-war are also being fitted with electric motors for fighting the guns. England, the (*quondam*) "mistress of the seas," still relies on the old systems, and, unless the inertia of the naval authorities be overcome by patriotic agitation, will have to learn the lessons which her electrical engineers are willing to teach, by bitter and costly experience.

The Cost of Steam Power.

Professor Unwin supplies to *Cassier's Magazine* a very useful table of coal and steam consumption of engines at special trials which will be of service as a reference in proportioning power installations. The table includes both condensing and non-condensing types, in each case both simple and compound. The best in the list is a triple Sulzer engine with jackets and 145 lbs. boiler pressure. It is credited with 11·7 lbs. water per horse-power hour, but this is on Sulzer's own authority. Still the next best is also a Sulzer on the authority of one Schröter, and the amount 12·2 lbs. The Willans triple expansion stands at 18·5, the compound at 19·2. Lancashire mill engines, on the unimpeachable authority of Mr. Longridge, stand for compounds at 17 lbs. Generally, it would appear that for condensing engines about 13½ lbs. steam per I.H.P., and about 15·8 per effective H.P. may be counted on for most favourable results. For electric light stations, the coal used per hour appears to be 3·8 lbs. per horse-power, or 7 lbs. per electrical unit generated in 1892, as measured in the best and largest stations. In small engines tested at Birmingham, the coal per I.H.P. has ranged from 8½ to 36 lbs., an amount sufficient to explain why power can be distributed from central stations at a profit. Clearly the steam engine is no motor for small powers. Figures appear to show that on a test trial the coal consumption is less than what prevails week in week out, the actual consumption for some large pumping engines exceeding by 35 per cent. the test rates. This shows what a fireman can do if put on his mettle; it probably also shows that a fireman, as a rule, finds the labour of shovelling an extra 35 per cent. of coal less exhausting than the close and careful attention necessary to secure the best results, but it also shows what a premium on coal saved and the employment of an extra fireman may produce. As a fact, most firemen are overloaded. Some steam users seem never satisfied unless the fireman is worried and begrimed. The best results are usually found where the stoker sits down half the day and admires his well cleaned boiler fronts.

The Electrical Profession and the two Services.

"What we want is theory applied to practice." This is the burden of an appeal in a recent issue of the *Journal of the United States Artillery*, by Lieut. Squier, Ph.D., who has been endeavouring to extract some lessons from the proceedings of the International Congress of 1893 and the electrical exhibits at the Great Fair. He complains that there is too much theory and too little practice: it is obvious also that the inertia of naval and military officialdom is quite as difficult to overcome in America as it is in this country. "Give us *at once* a suitable electrical plant at the Artillery School," he demands, so that the experts may get to work upon the problems and details of installation which they alone, probably, can work out by actual practice and experience under service conditions. There are search-lighting questions to settle, ammunition supply service to develop, central or group control to work out, proper range and position service to devise and co-ordinate, to say nothing of the other problems which we have recently commented upon in the Review, and which refer more generally to the handling of big guns and coast defence. These problems must be solved in the particular manner suited to naval and military organisation and to the new conditions which will obtain in practice. In America they are clamouring for the electro-technical education of officers. We have frequently suggested that there should be co-operation between the service and the electrical engineers. But why not go further? In view of the rapid adoption of electricity in innumerable ways by Continental powers as an adjunct to war, why not establish a new department in the services? We already have our engineers, and they are rightly regarded on shore and afloat as the "brains" of our fighting machines. Would it be too premature to establish departments of electrical engineers both in the army and the navy? Judging from present tendencies, our future coast defences should be manipulated by electrical power. Huge plants will be necessary, and these, like any other electrical installation, must be under the superintendence of competent electrical engineers. We do not, at present, possess these specialists in the services, *ergo*, steps should immediately be taken to train or procure them. In the Army and the Navy there are doubtless competent and willing hands ready to undertake their part in the development of a system of coast defence in keeping with the engineering practice of this electrical age, and commensurate with the vast interests now so totally unprotected; but we cannot afford to give them the opportunity. Such men are too scarce and, moreover, too valuable in other capacities. There is, admittedly, a dearth of engineers in the services, and those we have are too hard worked. This is especially the case on Her Majesty's ships, which will soon be crammed with electrical plant, each fresh addition involving further duties for the engineers. Such is one aspect of the case; the other is provided by the large number of young electrical engineers who crowd our workshops (or who knock at the doors of them), and are glad to accept wages which an ordinary carpenter would despise. These men are drawn, for the most part, from the better classes; they are usually well educated and often highly-trained. We believe that any number of them might be tempted by a very moderate inducement to engage in the service of their country. No better raw material for corps of specialists could possibly be found. The formation of such corps would immediately solve two problems which are, each in their way, of grave national importance, namely, how to obtain, at once, competent electrical engineers for the two services? and (2) what to do with the "gentlemanly out-of-works?"

RULES AND REGULATIONS FOR ELECTRIC LIGHTING OF STEAMSHIPS.

By RANKIN KENNEDY.

III.

Double Wiring.

Double wiring has been, by one of its advocates, said to be safer than single wiring, because if one main becomes earthed, there is no immediate danger. Perhaps not, but unfortunately in nearly every case of earthing, both mains usually get there about the same time. In double wiring we have double the length of wire exposed to accidents, and also double the number of joints to make and protect; and yet the same advocate asserts that double wiring has only half the chances of faults occurring. Strange logic this. So far as I can perceive, there is double the chances of faults occurring in double wiring. In single wiring a fault at once declares itself; no unsuspected earths can exist for a second. If water gets in between the main and the concentric return in single wiring, the outer concentric conductor is attacked, and may be eaten away without any danger in most cases, as there are usually several alternative return paths for the currents. If corrosion take place on any wire in a double wire system, a fire is the inevitable result, sooner or later.

Double wiring, however, is preferred by some people, and there is no reason why they should not have it, provided they get it put up on a good system; every joint should be watertight and protected, and the insulation resistances all right. There will be double joints to make all over, and double pole switches and fuses, double contact lamps, holders and fittings. In saloons, cabins, and other dry and sheltered places, branch wires may be run in wood casing, the joints being made thoroughly watertight; and here we may remark that while it is nice and easy to make a beautiful job of sample joints, in a workshop, with every tool at hand, and sitting comfortably on a seat with plenty of elbow room, it is quite another thing to make good joints on a ship. The man has to work in the most awkward positions and places, one time making a joint right over his head, at the imminent risk of blinding himself. Another time, in an alley-way or stokehole, or shaft tunnel, by the light of a tallow candle, doubled up, and with barely room to handle any tools. Surely the saving of such work is a consideration in choosing a system.

Iron pipes have been used by some contractors to protect the wires in exposed places; the iron pipe no doubt protects the wire where protection is least required, that is, between joints; but in every case of iron piping so used, which I have seen, the very places requiring most protection are not protected at all, that is, at joints. If some of those contractors who have taken up iron pipe protection would clearly illustrate how they make and protect ⊤, Y, +, ⅂, and other wire joints in iron pipes, and maintain a high insulation and watertight job, they would confer a benefit. On one ship referred to in the article on Jerry Wiring, where iron piped wires were used, they appeared more like drain pipes for water, the engineer remarking that the pipes would not keep out coals. In discussing the subject of the insulation of joints and the protection of wires, it cannot be too strongly insisted upon that the method of putting up, making good the cut, insulating the joints, and the closing out of all moisture, are the only points of interest. The insulation on the wire between joints is easily provided for, so is the protection of it; but, in dealing with the joints, we require skilled, well-paid, conscientious workmen who know their business, and the details of the method, whether it be single wiring or double wiring, with its protecting envelope, its junctions, its branches, joints, and even the termination of every branch must be carefully considered and worked out with as much knowledge and skill as the designing of the details of the engine and dynamo.

In practice, however, this is seldom the case. More often a young man, whose experience of wiring consists of making a few fancy joints at a laboratory table in a technical institute, is sent down to a ship with a cart-load of materials, some gasfitters, bellhangers, and two or three carpenters, and the wiring is proceeded with without any definite method, and without special appliances to meet the requirements in a ship. Under such circumstances, of what avail is it to specify certain kinds of insulation and high resistance, or to specify iron pipe protection and good joints? The insulating material would be there, but fearfully mangled, the high insulation resistance might be all there—for a time—the iron pipes would be there, but they would be used in such an unworkmanlike manner that they would be more a source of danger than a protection. As for the joints, those easily got at and visible might be passable, but those covered up or in difficult positions would possibly be more like those recently illustrated in the Electrical Review.

The ordinary two-wire system with rubber and taped joints in wood casing, and with every fitting having two joints behind it and two wires pulled through, may be good enough for house wiring, but however well carried out on a ship, it ends in trouble. Wherever double wiring is adopted a most complete system must be insisted on, with perfect mechanical protection, and it must be made perfectly plain to the most ordinary wireman how the joints are to be protected as effectually as the wire.

Lead covered wires meet such requirements most fully. Iron sheathed wires come next; both these require special ⅂, ⊤, +, and Y junctions. The lead may be jointed up by skilled plumbers, but cast junctions can be fitted to screw together and make a good joint; and as a mechanical protection in exposed places the lead covered wire may be further protected by iron wire armouring.

All this costs a good deal of money on a two-wire system. In fact, such a two-wire system is merely a double single-wire system, and what the advantages are in practice it is extremely difficult to say. A single concentric wire system would cost just half, and present just half the difficulties.

On the whole it would, in any case, be better to abolish both the more common systems now in use, namely, the two-wire, wood-cased, taped jointed, double contact fittings, with soldered joints behind, and the single wire wood-cased system with return wires earthed on ship's carcase.

The choice then remains between a single wire concentric return system with perfect metallic protection throughout, like Andrews's system, or the iron sheathed system with junction boxes, and a two-wire system, each wire with a perfect metallic protection throughout.

Rules without inspection might be of use, but inspection without rules would be worse than useless. Both inspector and inspectee would be guided and bound by rules, whereas without rules no end of trouble would crop up.

Inspection by means of a bridge and a few cells, to find the insulation resistance, is of no value whatever; neither is the testing of the engine and dynamo. If such a test is necessary, it should be made in the workshop. The inspector should see to the joints and their protection, especially in awkward places; he should see fittings before they are put up and after. No kid gloved inspection is of any use in such cases. A boiler inspector has to get into a suit of overalls, and crawl into flues and through manholes and round about inside a boiler for inspection. The electric light inspector would require to do a good deal of the same kind of work if inspection is to be of any practical value in securing sound workmanship.

HEILMANN LOCOMOTIVE FROM AN ELECTRICAL POINT OF VIEW.

The Heilmann locomotive has been considered from a mechanical engineering point of view in the preceding discussions; we would now draw attention to a few important considerations regarding electromotors and fluid pressure engines, such as steam engines, compared with each other for the purpose of traction on railways.

Considered as prime movers, the electro-motor and the steam engine are distinctly different in their principle of action, apart altogether from the difference due to the one being a heat engine and the other an electric engine. The electromotor takes up and converts electric energy on the

same principle as a steam or a water turbine does, and the useful work done by the current may be nothing, or it may be a maximum, just according to the speed of the armature or turbine wheel. If we lock a turbine shaft and turn on the steam or water full bore, the whole current of water will simply run to waste through the turbine, it will produce a torque but do no work, and so with the electro-motor; lock the shaft from turning, and any amount of current may be sent through the armature up to its full capacity; it only runs to waste; and although a torque is produced no work is done. Speed of the armature or wheel to which the torque is applied is a prime factor in the efficiency of this turbine class of prime movers, and failure to grasp this fact for many years retarded the progress of the electro-motor, until the $\frac{w}{W} = \frac{E}{e}$ law of Siemens was laid down, and showed us clearly that speed was the governing factor in the efficiency of motors. Electro-motors and turbines have only one speed at which the plant efficiency, and the efficiency of conversion, are at a maximum; as we reduce this speed, both efficiencies fall rapidly, until when stopped by force all the energy is wasted. This is all elementary knowledge, but yet we have a Heilmann locomotive actually built and running, and we have hundreds of electric locomotives in America wherein the motors must run at variable speeds—speeds constantly varying—and in work where the starts and stoppages are very frequent. Every time an electro-motor starts, a great flow of current runs to waste through it before its speed approaches that of efficiency; in fact, the speed of highest efficiency in an electric traction motor is very rarely kept up for any length of time, and, in consequence of thus employing electro-motors in traction where speeds are so variable, and starting so frequent, it is found in practice that the maximum output from a station working an electric railway is over three times the average output, and the plant must be equal to cope with the maximum power.

In running an electro-motor at variable speeds, and with frequent starts, we are working it contrary to the laws of nature, and, as a consequence, have to pay the penalty in loss of energy.

In traction work the speed of the electro-motor is governed to a large extent by the load; with a heavy load the speed falls and the torque increases, but the efficiency falls with the speed; the larger, however, the motor, the less is the fall in speed for a given increase of load, and consequently the less is the fall in efficiency. Hence, in practice, a car which can be run at normal speed on a level by a 3 H.P. motor is usually fitted with two 15 H.P. motors, and these are coupled to meet the great torques required at slow speeds. By this means the efficiency of conversion is improved, but the plant efficiency is reduced.

The law of the electro-motor is the same as the law of the turbine; it will run at high efficiency at nearly *constant speed*, with a variable load, which varies within well known limits, on a constant pressure supply. To get the maximum efficiency the speed should remain nearly constant within these limits of load variations, and it is needless to say that on a locomotive or tramcar, constant speed or anything approaching to it is just the one condition which cannot be obtained.

In factories and mills a constant speed and a variable load is the rule, and the electro-motor just meets the case, and there it runs at the highest efficiencies. Hence there is no reason why electric machines may not be interposed between a steam engine and any number of constant speed variable load machines which are usually started on very light loads.

To appeal to engineers, let us imagine a Heilmann locomotive in which the dynamo and motor are replaced by a pump and a water turbine. It is not difficult to estimate the losses without entering into calculations granted we have a pump as efficient as a dynamo. The steam engine would drive the pump, the current of water the turbine, and the turbine the locomotive, but every time the turbine was started from rest a large current of water would run through it without doing anything, and the whole energy in the water would not be available until the natural speed of efficiency was reached.

But let us substitute another type of motor for the turbine. Take a water-pressure engine with pistons in cylinders. In this motor the water cannot run through without doing work. If the wheels cannot go round the water does not escape. Every cylinderful of water sends the wheels round half a turn, else it cannot get free, and if it goes slow the water escapes slowly. Here we have a motor designed by nature for traction purposes, and so it is with the steam engine; its very nature fits it exactly for traction work; it can pull strongly at a start without any steam escaping until the wheels move. This type of prime mover acts by *dead weight*, while the other type acts by change of velocity in a moving fluid.

In the Heilmann locomotive, we have the steam engine which, by nature, is designed for traction, and efficient at starting and variable speeds, set to work a dynamo at constant speed, and the electro-motor is applied to work under conditions naturally the very worst for its efficiency, *i.e.*, frequent starts with full load, and variable speeds.

In electric traction, where the power is sent to the moving vehicles by the wire, the case is different; here the engineer has to face the inevitable, and it speaks volumes for American courage and enterprise, that in the face of such natural difficulties, electric traction has made such extraordinary progress; but to deliberately put in a dynamo and motor between a steam engine and the driving axle on a steam locomotive in the year A.D. 1894, is such an obvious absurdity, that one could not entertain the idea as a serious proposal, until we heard that it was actually being put into shape. Electricity, in its progress, has suffered much from the promotion of wild cat schemes which never seem to fail in securing financial support, while genuine improvements and inventions are either pirated without as much as thanks to the inventor, or altogether neglected.

Electric traction in cities has so many great advantages, that the losses due to the unnatural conditions under which the motors do their work are amply compensated; but if they carried their own boilers, engines and dynamos, the common steam tramways would leave them far behind in the competition.

For long runs at a high speed without a stop, electric traction has been put forward as superior to steam. It may be so, but steam engines are prepared to go up as far in speed as any electro-motor. High speeds and long runs are not wanted, however, just at present; when they are, the rival powers will no doubt be brought to a practical test. The promoters of high speed railways talk glibly about 100 to 200 miles an hour, without showing the slightest knowledge of the great field of investigation before them, and which must be tackled before even a beginning can be made towards such speeds.

The promoters of high speed railways usually fasten on "electricity" as a word to conjure with, though in the present state of electric traction we cannot see why they should expect electricity to be more successful in high speed railway work than steam would be. Progress requires to be made—and no doubt is being made—in electric traction, but this talk, as if the problems of high speed travelling were now solved by "electricity," without any indications as to how it is to be done, usually has for its sole object the reaching of the pockets of investors. The existence of a Heilmann locomotive, and the many high speed railway proposals, clearly prove that the laws of the electro-motor are, even yet, imperfectly understood, after all that has been said and done.

ARC LIGHTING.

By E. TREMLETT CARTER.

(*Continued from page* 664, *Vol.* 33).

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XIV.

17. *Alternate Current Lamps for Series Working.*—The substitution of an alternating for a continuous current introduces three new principal elements into the action of the lamp. These are: self-induction in the solenoids and

other magnet coils, eddy currents in masses of unlaminated metal in the field of these coils, and uniform and similar consumption of the two carbons. The first two of these affect the design of the mechanism; the last affects the character of the light and the size of the carbons. In the arc itself the alternating current produces a rapid series of extinctions and re-ignitions, one effect of which is to produce physically a fluctuating light, another effect being to cause the arc to emit a more or less loud musical note, the pitch of which will depend on the frequency of the current alternations. Physiologically, there is not necessarily any fluctuation of luminosity on account of the pulsations; for the phenomenon of persistence of vision tends to smooth away these variations of intensity, and will completely do so when the alternations are more frequent than about 40 per second. Although thus several times a second the operation of the current in producing light is momentarily suspended, yet, even physically, there is not complete darkness in the brief intervals between the actions of the current; for the ends of the carbon rods retain sufficient heat to keep them constantly glowing, though with much dimmer light. The physical fluctuation of light is thus of less amplitude than the fluctuation of current, owing to the heat capacity of the carbons; while, with a current of high frequency, the physiological fluctuation of luminosity is practically *nil*. It must be observed that the residuum of carbon vapour which lingers between the carbon points during extinction will render it unnecessary that the points should come into actual contact at each re-ignition, the arc re-starting at each current alternation without any change in the relative position of the carbons. An alternating current arc can be maintained between carbon points with a much lower minimum voltage than where the current is continuously in one direction, partly because the pressure in the former case rises considerably above its average value.

If we take an arc lamp, such as the one described in the last section, which has been designed to run in series with other lamps on a continuous current circuit, and send an alternating current through it with a view to running it, we shall notice several important phenomena. In the first place, without some considerable adjustment of the regulating spring it will be impossible to get a steady light for more than a minute or two; because the equilibrium of the shunt and main coils is not the same with alternating currents as with continuous currents. But if we so alter the spring, or in some other way adjust the mechanism, that the lamp will regulate fairly well, we shall next notice that to get the same light as before there must be a higher voltage at the terminals. Presently the lamp will suddenly stop running; and when we take hold of the mechanism to see what is wrong, we find that it is all nearly red hot. The additional volts will be required on account of the increased impedance of the main coil, consequent on its self-induction. The development of heat in the mechanism, which was the cause of its ultimate failure, would be found to be due to the heating effect of the eddy currents induced in the magnet cores, in the yokes, and in every piece of unlaminated metal which happened to be in the magnetic field of the magnets.

One of the most common ways of laminating a straight solenoid core is to make it in the form of a longitudinally split tube of the softest iron, as this preserves the necessary rigidity and strength of the core. The usual mode of laminating dynamos and other magnet cores, namely, by building up a figure out of punchings of iron plate and strips of varnished paper, is not to be recommended here; it is more expensive, and the core is less rigid and more liable to stick than the split tube. Care must always be taken that the end contacts between the core and the bridge piece do not provide a short circuit across the core; and this bridge piece, or yoke, must itself be well laminated. A high rate of magnetic induction is to be avoided; that is to say, plenty of iron section must be provided; moreover, it is always well, where possible, to give the magnetic lines as complete an iron path as is consistent with the working of the mechanism. The purpose of these precautions is to avoid stray magnetic lines, which may otherwise wander about the mechanism case, heating every bit of metal they come across; and these stray lines must be prevented from passing in any great number through the solid case itself. When this has been done, the space around the solenoids should be tested for stray lines while the current is full on; and these should either be got rid of, or metallic masses in their midst must be laminated. Stray lines wandering about may conveniently be got rid of in such a case as this by placing a small bundle of varnished iron wires to conduct them in the way they should go. The objection to stray lines is not so much that they waste energy, but chiefly that they are liable to heat the working parts of the lamp and cause a breakdown.

The design of series and shunt coils for these lamps, as well as an account of the distribution of light from an alternating arc, will be dealt with in their special sections. Except in those respects which have been mentioned, the design of an alternating current lamp follows the lines of the continuous current lamp laid down in section 16.

18. *Continuous Current Lamps for Parallel Working.*—In a system of distribution to lamps in parallel, the mains are necessarily maintained at a fairly constant voltage. No lamp, however, will work satisfactorily if its terminals are supplied with power at an absolutely constant number of volts. There are two reasons for this: in the first place, it is desirable that the fluctuations in current shall be small compared with the fluctuations in the resistance of the arc, so that there shall be a tendency to steadiness of light; in the second place, where regulation is effected by shunt control, it is desirable that the volts shall rise as the arc grows longer. There is a third reason, which relates to the generating and distributing plant; it is, that were the volts kept quite constant at the terminals of the lamp there would be too large a current through the lamp, and too great a drop in the mains, when the carbons come into contact. For several reasons, then, it is desirable that the voltage on the lamp should vary inversely with the current through the carbons; that the voltage should fall when the arc is striking, and rise when it requires to be fed. In other words, it is desirable to frame the conditions so that the lamp shall behave as if a series dynamo with a very drooping characteristic were working close up to its terminals.

Yet the voltage on the mains must be constant. And the only way to reconcile these conditions is to employ a *steadying resistance* in series with the lamp. This consists of a small low-resistance rheostat, capable of absorbing from 8 to 12 volts with the normal current. When the lamp is working steadily the only thing this resistance does is to waste about 12 or 15 per cent. of the power taken from the mains, which makes the method a rather inefficient one. But when the current tends to increase, this steadying resistance promptly absorbs a larger number of volts, and when the current diminishes it absorbs a reduced number, thereby regulating the volts at the arc in the desired way.

In parallel working the lamps are sometimes placed in simple parallel across mains at about 60 volts, and sometimes in pairs across mains at from 100 to 105 volts. In the former arrangement the distribution of volts is normally as follows: 39 volts for the apparent back E.M.F. in the arc, 2 volts for the real resistance of the arc, 3 to 4 volts for the carbons, 1 to 3 volts for the main coil, and the remainder for the steadying resistance. In the latter arrangement about 96 to 100 volts will be absorbed by the two lamps and the leads connecting them, and the remainder by the resistance coils. It will be evident that, from the economical point of view, there is no necessity to design the main coils of arc lamps in this class to waste but a small amount of power; it is only necessary to design them to work at a sufficiently low temperature. The steadying resistances may often be conveniently placed in a cavity in the base of the lamp post.

This class of lamp is very frequently regulated entirely by means of a single main coil. The arc is struck by virtue of the large current which passes when the carbons come into contact, and it is fed when the pull of this magnet becomes enfeebled, as compared with that of an opposing spring, the direct cause of the enfeeblement being the lengthening of the arc. Such a mode of regulation is most commonly used in the simple parallel arrangement; as, if it were used where two lamps are placed in series across the mains, there would not be independent regulation of these two lamps. With the series-feed mechanism it is not advisable to have a very large number of volts spent on the steadying resistance, otherwise the current will be fairly constant over a considerable range of position of the carbons, and the lamp will not regu-

late for constant candle-power. On the other hand, where there is a considerable reserve of volts on the steadying resistance, it is possible to regulate effectively by means of a shunt-feed coil, and more steady lighting can be ensured by this method. In such a case an ordinary continuous current "series" lamp can be used, the only necessary precaution being the removal of the hand-switch for short-circuiting, and the cut-out device for the same purpose. Lamps in parallel must never be short-circuited, and they require no automatic cut-out. Where the entire function of the regulating mechanism is supplied by a main coil, it is necessary that the carbons shall be in contact when the current is started, and for this purpose the balance of the mechanism must always, in these lamps, be designed so that when the current stops, it shall entirely release the top carbon holder, and let it slide down until the carbon ends are touching. But in the other class of parallel lamp, where the feed is actuated by a shunt coil, it is possible—and with certain dynamos it is preferable—to have the carbons initially separate from one another, since when the voltage is put on the mains, the shunt coils will come into action, and will cause the carbons to approach till they touch. The advantage of this latter practice is felt in cases where it is not desirable for the circuit to have a very low starting resistance.

The Gülcher arc lamp is a type of this class, being specially designed to work on low pressure parallel circuits. The construction of the regulating mechanism can be seen by reference to figs. 44 and 45, which show a plan and elevation

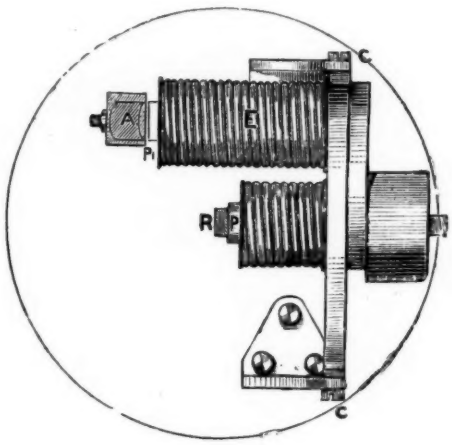


Fig. 44.

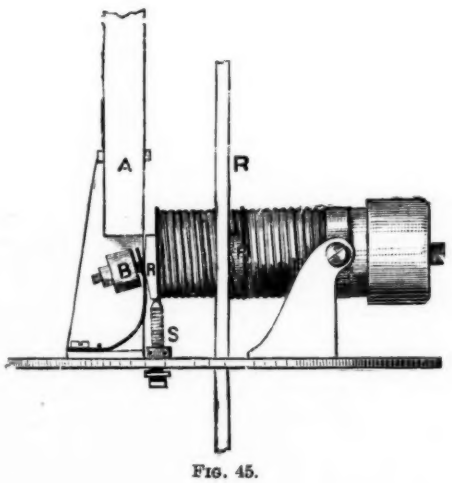


Fig. 45.

respectively. An electro-magnet, E, consisting of two unequal series wound coils with a soft iron core, is pivoted on the centres, C, C. The main current produces two poles, P, P_1. Immediately in front of the shorter limb of the magnet is a long flat strip or bar of soft iron, to the lower end of which the positive carbon holder is fixed. This rod slides up and down with the carbon holder, and is shown at R. Immediately in front of, but a little above, the longer limb is a fixed slab of soft iron, A. A stop, S, prevents the magnet falling too far below this soft iron slab. Just below A, and directly in front of the pole, P_1, is a soft iron button, B, attached to a spring. This, when magnetically attracted by the pole, acts as a friction brake, exerting a retarding force which is proportional to the current and preventing excessive motion of the magnet on its bearings. Normally, the carbons are in contact; but when the current is switched on, the pole of the short limb clips the iron band magnetically, while the pole of the long limb is attracted upwards by the iron, A, and the entire magnet rocks upwards on its pivots and strikes the arc. Feeding takes place when the magnetic grip is insufficient to hold up the weight of the iron band and the top carbon; but as the current falls slowly the feed is most gradual and gentle. The positive carbon, which is always uppermost, is connected to the movable frame carrying the lower carbon by means of a silk cord which passes over two pulleys, the arrangement providing perfect focussing throughout the entire range of the carbon holders.

(*To be continued.*)

RELATIVE ECONOMY OF COPPER IN SINGLE-PHASE, TWO-PHASE, AND THREE-PHASE TRANSMISSION.*

By W. S. R. EMMET.

In the report of Prof. George Forbes's paper on "The Electrical Transmission of Power from Niagara Falls," begun in the *Electrical Engineer*, of December 20th, the following statement is made:—

> With regard to the relative merits of two and three phases, several claims that cannot be supported have been put forward in favour of the latter. First, it is claimed that the saving in copper on the line is 25 per cent. over a one-phase system, and 25 or 13 per cent. over two-phase system, according as four or three wires are used for the purpose. I investigated this matter carefully, and arrived at the conclusion that this was not the case, and that the three-phase system had no advantage in this respect over a two-phase system with three wires.

In a paper read before Section "G," of the British Association, on September 18th last, Mr. Gisbert Kapp makes the following statement:—

> If we put all the systems on the same footing as regards efficiency and safety of insulation, we find the following, viz.: If for the transmission of a certain power over a given distance by continuous current, 100 tons of copper are required for the line, then the single-phase alternating, and the two-phase four-wire system will require 200 tons, the two-phase three-wire system will require 290 tons, and the three-phase three-wire system only 150 tons. As far as the line is concerned, there is thus a distinct advantage in the employment of the three-phase system.

The facts concerning which these gentlemen disagree are of great importance, since the use of multiphase apparatus is daily increasing, and every user has to decide between the two and three-phase systems, each of which is advocated by one or more of the large electrical companies of the country. That the figures given by Mr. Kapp are correct within the premises he assumes, is easily shown by the process given below.

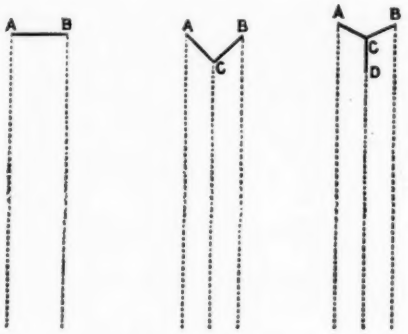
Figs. 1, 2, and 3 represent three circuits arranged, respectively, on single-phase, two-phase, three-wire, and three-phase systems. The dotted lines represent the line wires, which are all assumed to be of equal length. The full lines represent the portions of circuits on which work is done or light furnished. We will assume that the maximum potential difference between any two wires in each of these circuits is the same, and equal to E; also that the energy in watts in the useful part of the circuits in each case is equal to W, and that the energy lost in lines in each case is the same and equal to K. M and N are constants which reduce the quantities which are expressed in maxima to mean values, then apply in the same manner to the corresponding quantities in each case.

In fig. 1 the current in each of the line wires is $\frac{W\,M}{E\,M}$

* New York *Electrical Engineer*.

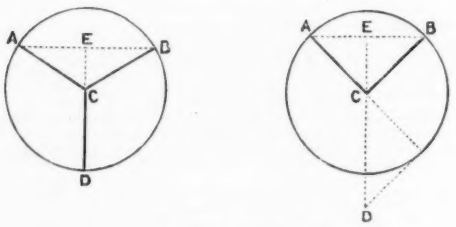
and the resistance of each of the wires is $\frac{K}{2} = \frac{W^2 N}{E^2 N}$, and the conductivity of each is $\frac{2 W^2}{E^2 K}$. Hence the total conductivity in line wires is $\frac{4 W^2}{E^2 K}$.

In fig. 2 the maximum potential difference between the points A and B being E, the maximum difference between B and C will be $\frac{E}{\sqrt{2}}$. In fig. 5, in which A C and B C repre-



Figs. 1, 2, and 3.

sent the maximum potential differences between the points A and C and B and C, fig. 2; and the angle A C B is equal to the difference of phase of these quantities which in the



Figs. 4 and 5.

two-phase system is 90 degrees. Then A B = B C $\sqrt{2}$ will equal the maximum potential difference between A and B, or E, by the simple relation of periodic quantities, the variations being assumed to be sinusoidal. The current in each of the branches A C and A B, fig. 2, will then be $\frac{W}{2} \times \frac{\sqrt{2}}{E} M = \frac{W M}{E \sqrt{2}}$. These currents flow in the line wires from A and B, and they combine at C to form a current in the line wire from C, which will bear the same relation to either of the currents which form it, that A C or A B bear to C D, in fig. 5. These two combining currents are equal and differ in phase by 90 degrees. Hence the current in line wire from C is $\frac{W M}{E M}$. Thus the total current carried on the three wires over the single length of the line is $\frac{W}{E} \times (1 + \sqrt{2})$. The total energy loss in lines being K, the total conductivity of the three wires which carry this current must be $\frac{W^2}{E^2 K} \times 5{\cdot}83$.

In fig. 3 the three circuits, A C, B C, and D C, carry equal currents, two of these currents, which differ in phase by 120 degrees, uniting to form a periodic current equal to each of those from which it is formed. If A C and B C, fig. 4, represent in quantity and phase the currents at A and B, fig. 3, then C D will represent in quantity and phase the current at D, fig. 3, and if B C and A C, fig. 4, represent the corresponding potential differences in fig. 3, then A B, fig. 4, represents the maximum potential difference between wires which exists on the system, this being assumed equal to E.

The maximum difference between the point C and any of the points, A, B, or D, is $\frac{E}{\sqrt{3}}$. Then, since the total energy is W, the current in each branch is $\frac{W M}{3} \times \frac{\sqrt{3}}{E M} = \frac{W}{E \sqrt{3}}$. The total current carried the single length of the line is $\frac{W}{E} \sqrt{3}$, and since the $C^2 R$ loss in the line is K, the total conductivity must be $\frac{W^2}{E^2 K} \times 3$.

Hence, the conductivities required are found to be in the proportion of 4, 5·83, and 3. These proportions are the same as between the numbers 200, 291, and 150, which correspond to the copper weights given by Kapp. Since the only limitation of economy in copper in any line is determined by the pressure which can be safely and conveniently generated and handled, it would seem that no rational basis of comparison can be assumed other than that from which these figures are derived; namely, the assumption, that in lines of equal length equal amounts of energy are transmitted, and equal amounts are lost in lines, with equal strain on insulation and danger from shocks.

NEWSPAPER SCIENCE.

A Strange Tale of a Motor.

It gives us pleasure to announce that we have been instrumental in "discovering" a new writer. But for fortuitous circumstances his peculiar genius might have remained unrecognised, and his primordial talents wasted on an unappreciative rural folk; it was ordained otherwise, and our "discovery" is another tribute to the penetrative qualities of the age, which have detected the inordinate cleverness of "Screams," "The Celestial Triplets," and certain other manifestations of an electrical age.

His theme is the electric motor. Till to-day electrical men never dreamt of the poetry of motion which exists in a machine of ½ horse-power. At times we have sadly pondered on the difficulty of clothing electrical subjects in literary form. But a writer has risen who can invest the prosaic commonplace motor with a dignity of language which transcends all previous efforts. To call a spade a spade may not require any special training, but he that can call it, without hesitation, "an implement of husbandry," may achieve the most ambitious heights. He may live to be a Prime Minister or a writer of quack advertisements.

The writer to whom we allude has had perforce to select for his lucubration so humble a medium as the *Coatbridge Express*. It is the lighting of Coatbridge which has filled him with the divine afflatus, for, with a Gladstonian turn of phrase, he says that—

> Now that it has come within measurable distance that the burgh of Coatbridge shall be illuminated with the electric light, it may be fair to give an illustrative article gleaned from the most authentic sources.

Chambers's Journal is one of the sources. Then tempering imagination with fact, he incidentally mentions that

> The searchlight must be the means of preventing much crime at night in the crowded thoroughfares of our great cities, while in times of war a sudden attack by an enemy under cover of darkness will now be impossible.

The adaptability of the electric light does not fail to impress him, but it may interest even electrical men to learn that it may be "hitched" on or off as required. Then, in the unkindest manner, this knight errant of the pen proceeds to "strip the dynamo of its technical details;" after which operation, it becomes

> A machine for transforming energy. It converts mechanical power into that phase or manifestation of energy which we call electricity. Mechanical power is cheap, and the dynamo made electricity cheap.

The real force of the writer, however, as we suggested, is centred on the motor. Its poetic side, its idealistic attitude, its imaginative aspect, all appeal to him. In his eyes it is something more than a mere machine, having a certain or uncertain output, with a strong tendency on a lighting circuit to make lights blink. With an admirable sense of humour, possibly Scottish, he declares that electric motors are now a regular trade product, and can be bought "ready made." Then its marvellous adaptability to all conditions dawns upon him, for

> It can be placed in any position, right side up, upside down, or affixed sidewise to a wall, and will deliver power from its pulley in any required direction.

The gymnastic properties of the motor duly recorded, we are gravely informed that "larger motors occupy more space in proportion." We had no idea that a large motor could be so funny. Another property possessed by a reasonably well-conducted motor is, that "it is practically cold."

He appreciates, with great nicety, the distinction between dynamics and statics, for with coolness, possibly due to the aforesaid cold motor, he announces that, "when not at work, the motor is at complete rest." We trust sincerely that our readers will not suffer from grasping too hastily this dazzling and startling Coatbridge effect. The statement is not ours, and without reproducing the exact conditions prevailing at Coatbridge, we are not sure that experiment would demonstrate the fact to our complete satisfaction.

It may surprise some to learn that this statement did not conclude the article, and to the best of our belief the writer is yet alive. At any rate he existed long enough to perpetrate the following:—Pointing out the danger of the leakage of gas into the subsoil, he says that when pipes are buried in a non-porous earth, such as clay, "it is reduced to a *maximum*."

Then comes a great and dramatic appeal on behalf of the sewing women; it fills him with sadness when he reflects that, under the old order of things:—

> We find sewing women crowded into a hot, stuffy room, close to the noise, smell, dust, and terrible heat of some little steam engine.

The saddening effects of such a picture would move a motor. But a brighter prospect appears at the touch of the magician:—

> We take the elevator in a wholesale clothing warehouse, and pass through the salerooms to the top floor. The building is lofty, and of light construction, and yet we find in the bright and pleasant attic above the house-tops a hundred girls, each using power. . . . The operator has only to touch a small foot pedal, and the motor starts, giving a tenth of a horse-power at very high speed. . . . Each operator, with a touch of the foot, throws her machine into gear, and takes her share of the two horse-power.

This is electricity! By the waters of Coatbridge, we sat down and wept.

ANOTHER EARLY TRANSFORMER WITH CLOSED MAGNETIC CIRCUIT.

By A. M. TANNER.

Another contribution to the early history of transformers, or inductoriums possessing closed magnetic circuits, is the British patent of Thomas Allan, dated June 24th, 1852, No. 14,190. The specification of this patent states that: "the first part of my invention consists of improvements in producing induced electric currents by means of electro-magnets, which currents are applicable to various useful purposes. For the purpose of thus producing induced electric currents I compose an electro-magnet, or combination of electro-magnets, of several straight pieces of soft iron so as to form an electro-magnetic circle, and I prefer to form such magnet or combination of four pieces, but it may be composed of three pieces, or of five or more such pieces. I cover these pieces with the primary coil of insulated wire and then place the secondary coil, also of insulated wire, around the primary coil and the pieces being straight they may have the coils wound upon them in a lathe with great facility. The pieces, having had the coils put upon them, are then to be connected together at their ends so as to form, when electro-magnetised, a complete electro-magnetic circle. The wires of the primary coils are then to be connected together so as to form one continuous primary coil, the two ends of which may be connected with a battery in the ordinary manner. The wires of the secondary coils around the pieces of the magnet or combination are also to be connected, so as to form one continuous secondary coil, the two ends of which are to be connected with the line wires of an electric telegraph apparatus, or with the wires of any other apparatus to which the same may be intended to be applied.

"In figures 1, 2, and 3, I have shown the mode of constructing an electro-magnet, or combination of electro-magnets of this description with four straight pieces of soft iron.

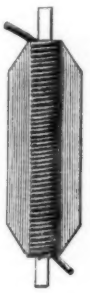


Fig. 1.

Fig. 2.

"Fig. 1 shows a straight piece of iron with the primary coil wound upon it, the ends projecting a little beyond the coils.

"Fig. 2 shows the same straight piece of iron with the secondary coil also wound upon it, and the end of each of the coils are left long and projecting so as to be ready to be connected with any other wires.

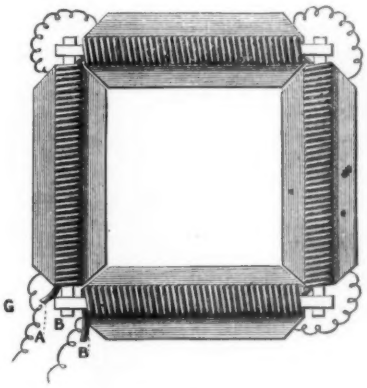


Fig. 3.

"Fig. 3 represents four straight pieces of iron with primary and secondary coils around them, as already described, and the pieces joined together at their ends by nuts, screws, or other means, so as to form an electro-magnet. The primary coils around the pieces are also joined together so as to form one continuous primary coil, the ends, A and B, of which are shown projecting and ready to be connected with the wires of the galvanic battery, which may be intended to be used. The secondary coils are also joined together in like manner so as to form a continuous secondary coil, the ends, G and H, of which are shown projecting and ready to be connected with the wires of any apparatus to which the induced current of electricity may be intended to be applied."

The patent drawing relating to the transformer part of the invention is reproduced to illustrate the construction, which is very much like that of some modern transformers in which the primary and secondary coils are wound continuously in the same direction on the core sections. It will be seen that the description is silent as to the lamination of the core sections.

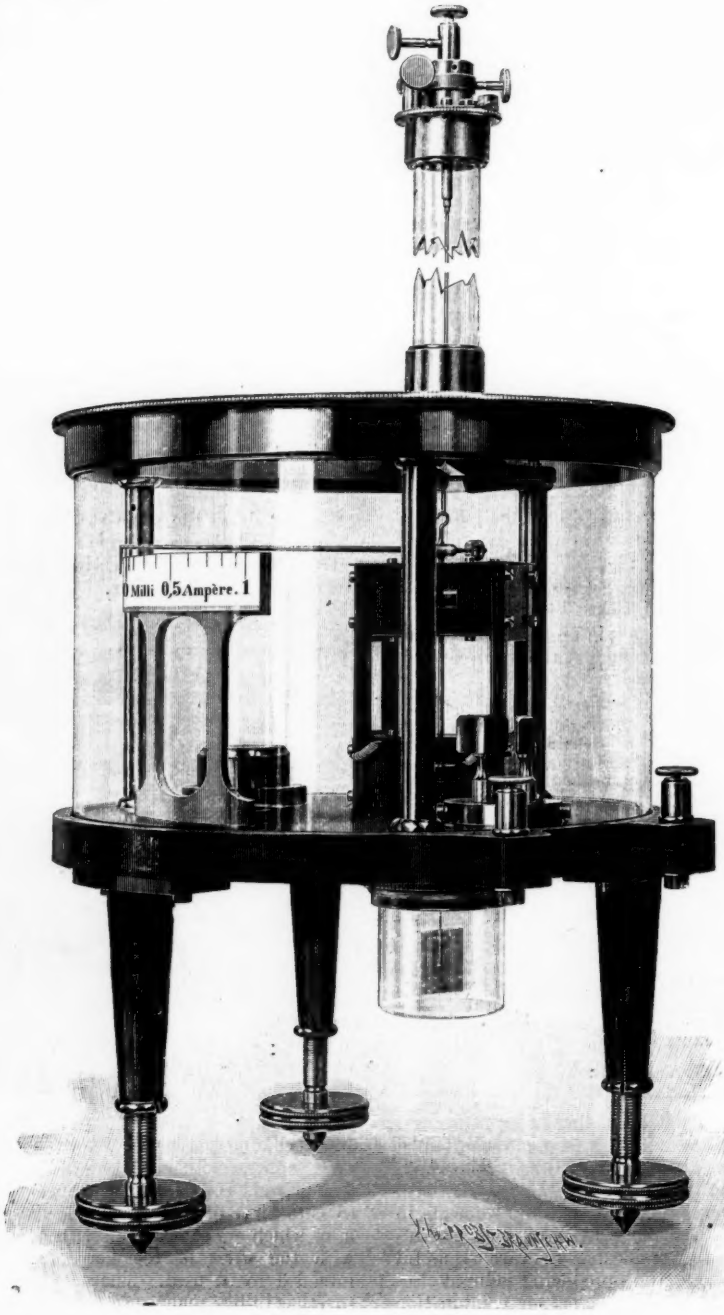
A NEW ELECTRO-DYNAMOMETER.

Some time ago, an electro-dynamometer was constructed by J. W. Giltay on the well known principle of Bellatti. The instrument was very favourably received, but it was recognised that its usefulness might be greatly extended if it were capable of being standardised. Terrestrial magnetism exercised a very disturbing influence on this instrument, so that the reversion of a battery current flowing through it was attended with undesirable results. The difficulty has now been gotten rid of, and in a recent number of the *Annalen der Physik und Chemie*, a new form of apparatus is carefully described.

The essential part of the instrument consists in two bundles of iron wire, in every respect similar to one another, which are suspended parallel to and above one another in similar coil frames. The turns of wire in the coils are similar in arrangement and equal in number. When a current is sent into the apparatus it circulates through both coils in opposite directions, and magnetises the iron bundles in such a way that they form an astatic system. In this manner the disturbance due to terrestrial magnetism is eliminated, and it becomes possible to standardise the instrument accurately.

In his paper, Giltay describes with great minuteness the precautions which he observed in standardising, and he makes use of the term "astasia" very frequently to denote the condition of the superimposed, parallel core bundles. There are also a number of tabulated results obtained from typical experiments illustrating the use of the instrument.

We may here observe that this paper is characteristic of that diffuseness which is so common in accounts of German research. In whatever else English scientists may fall short, they certainly do not, fortunately, err in this direction.



In the figure is shown a general view of this improved electro-dynamometer in a form which is specially designed for electro-therapeutic purposes. The index has a length of 11 cm.; it is marked by means of an aluminium needle. Each iron-bundle consists of 116 wires of 0·3 mm. thickness and 18 cm. length. These are suspended by means of raw silk fibres

situated 1·2 mm. apart. The index is parallel to them and makes, with the plane of the coils, an angle of 47°. Beneath the floor of the apparatus is a level and an ordinary plug commutator. When the two plugs are inserted in the proper holes the instrument is astatic, and is suitable for use with battery currents. When, on the other hand, the two plugs are placed in the other holes the instrument is ready for use with induction currents. Devices are inserted which make it impossible to injure the instrument by making wrong connections.

The theory of this electrodynamometer is, of course, the same as that of Weber's electrodynamometer.

The instrument illustrated, was constructed for Dr. J. L. Hoorveg at Delft. An account of it, by him, appears in a work entitled "Die Medicinische Electrotechnik und iten Physikalischen Grundlagen" (Leipzig, Engelmann), pp. 70, 129 and 130, where the methods of applying it in therapeutics are indicated and discussed.

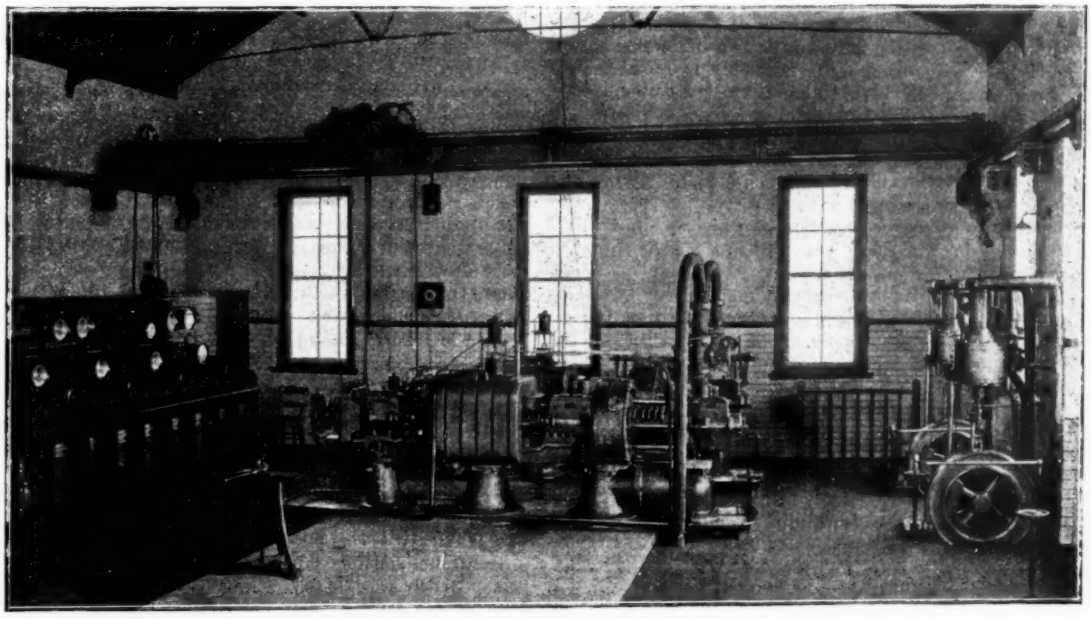
ELECTRICITY SUPPLY STATIONS.

No. 15—Scarborough Electricity Supply Company's Works.

When the Corporation of Scarborough obtained a provisional order in 1891, it was generally supposed to be a preliminary step towards the inauguration of a municipal supply. The municipal authorities, however, on further consideration, deemed a public system too risky and declared themselves ready to sell their rights to a properly constituted company. There does not appear to have been much difficulty in forming a limited liability company and raising the necessary capital. A good deal of the capital came from over the borders, for there is plenty of confidence in electricity supply business out Newcastle way, engendered, no doubt, by the highly successful working of the local companies. We believe we are right in saying that most of the shareholders in the Scarborough Electricity Supply Company, Limited, hold shares in one of the Newcastle companies. Mr. A. A. Campbell Swinton had a great deal to do with the formation of this company, Mr. Bernard Drake representing the interests of the Corporation. In consequence of the successful negotiations, the Corporation transferred their provisional order to the company, which started with a nominal capital of £50,000. Local interests are well represented in the directorate of the company, the chairman being Lieut.-Col. Steble, a former Mayor of Scarborough, and most of the other directors are residents of the neighbourhood. The terms arranged between the municipal authority and the company are distinctly favourable to the former. It is agreed that the Corporation may purchase the undertaking at the end of 21 years, 32 years, or any subsequently completed period of 5 years. If the Corporation exercise their option of purchase at the end of 21 years, they are to acquire the undertaking on paying the full value of the business as a going concern. If the option be exercised by them at the expiration of 32 years, or any later period, they agree to pay for the undertaking on the terms which, according to the Statute, usually take effect after the expiry of 42 years. The Corporation very wisely inserted in the agreement, special provisions relating to reductions in the price of current to consumers, but of these we will speak later.

The Site of the Station.

After casting about for a suitable site and considering many places, the engineers of the company eventually decided to erect the works on a piece of ground situate on the outskirts of the town. Being building land it was not cheap, but it afforded fairly good access to the railway which is not above a hundred yards away. The site is situate at the foot of a hill, a natural basin at the bottom being converted into a condensing pond. The surface water from contiguous land will drain into this pond, but in the event of a dry season the town water can be turned into it. The question of erecting the generating station near the shore and using sea-water, seems to have occupied the attention of the engineers, but it being expected that the sand in the water would cause trouble, the project was abandoned. In its present position the company is not likely to be indicted for nuisance, a condition not altogether to be despised nowadays.



View of Generating Room.

The System.

Briefly, the system is a high pressure alternating one, with street and house transformers. Current is generated at 2,000 volts, and for the most part is transformed down in street boxes and sent through low-pressure distributing mains to the consumers, though, in some cases, transforming is done on the consumers' premises. Where the consumers are fairly numerous, the street-box transformer is used, but when the houses to be supplied are scattered, the house transformer method is adopted. The alternators are coupled direct to Parsons turbines.

Although, in many respects, the system is similar to the

one employed at Cambridge, there are several interesting features which we will mention.

The Works.

The generating room has an exceedingly bright appearance, being lofty and well lighted. It is fitted with an overhead traveller which runs the entire length of the room. The generating plant at present erected, consists of two Parsons condensing steam turbine alternators, each designed for an output of 150 kilowatts. Each is entirely independent of the other, and consists of a compound steam turbine arranged for multiple expansion from the 130 lbs. per square inch boiler pressure down to a condenser pressure of ½ lb. absolute, or a range of about 250 fold expansion. The turbine revolves at 4,800 revolutions per minute, and is coupled direct to a two-poled alternator giving 75 ampères at 2,000 volts with a periodicity of 80 complete alternations per second. To the same spindle is coupled the exciter. An automatic variable cut-off valve gear and governor, electrically controlled, maintains a constant E.M.F. and enables the full range of expansion to be maintained at light loads, thus securing an exceptional economy of fuel on the all day load. One of the two machines at Scarborough was tested for steam consumption in March last by Professor Alex. B. W. Kennedy, and gave exceedingly brilliant results. The figures obtained by Prof. Kennedy were published in the Electrical Review for July 28th, 1893. It will be remembered that while the steam consumed at full load was slightly less than 20 lbs. per E.H.P., at ¾ load it was only 21 lbs., at ½ load 23 lbs., and at ¼ load 29 lbs. per E.H.P.

The turbine alternators stand upon a solid bed consisting of stone walls filled in with rubble and cemented over the top, which runs the whole length of the engine room occupying a middle position between the two side walls. As already mentioned, there are at present only two machines, but the engine room itself and the bed have been constructed of sufficient size for five additional machines. There is ample room for the additional machines to be of larger size than the present ones; in fact, the engineers of the company expect that the present station will house plant having a total output of 2,000 electrical horse-power.

Jet condensers are used, the action of which is similar to those employed at Cambridge, described in the Electrical Review for September 1st, 1893.

The main steam pipes are arranged on the ring system, they are of cast-iron, the ends and the closing lengths, however, being of solid drawn copper. The usual facilities for cutting off any given section for repairs are provided. Generally speaking, the whole of the pipes are carried underneath the engine room floor, and although out of sight, they can easily be inspected. As a matter of fact, the space underneath the engine room is ample, and in this respect is a great improvement upon the Cambridge arrangement.

Two Worthington pumps supply feed water to the boilers, and the exhaust from these is utilised in a Berryman feed water heater for heating the feed water before it passes to the boilers. The exhaust steam from the condenser engines can be used in a similar manner.

Two boilers are at present erected, though the present house will hold an additional one. The measurements of the boilers are 28 feet long and 7 feet 8 inches in diameter. They work at a pressure of 140 lbs. It will be easy to extend the boiler house for additional boilers when required. One would naturally expect to meet in a station on the Parsons plan a super-heating arrangement and a Syke's super-heater is provided. It is placed in the main flue with by-pass dampers, so that it can be put out of use when required; additional dampers permit the direct flame from the internal flues of the boiler to reach the super heater direct instead of after passing along the side flues of the boiler.

It is unnecessary to say more about the great economy effected in the Parsons turbines by the use of super-heated steam. The fact was brought prominently forward in our extract of Prof. Kennedy's report, and we referred to it when we published a description of the Cambridge station.

The Switching Arrangements.

It will be seen from our illustration that the switchboard is arranged on the side of the engine room. It is provided with apparatus sufficient to deal with three alternators and four supply circuits. Each alternator has its own voltmeter, and separate ammeters are provided for each alternator and each circuit. A Thomson wattmeter is placed in each alternator circuit. The switches are of the lever throw-over type, which instantaneously change the circuit from one alternator to another. There is nothing new in the arrangements, and for details and drawings of this system we refer our readers to the issue of September 1st, 1893.

The Mains.

The mains are rubber covered cables laid in iron pipes. They are of Silvertown manufacture, the joints being usually vulcanised *in situ*. The high tension mains, which are mostly 7/16, are of the 6,000 megohm per mile class, the low tension cables giving 600 megohms per mile. In the case of one consumer whose house is in an isolated position at some distance from the town, Fowler-Waring concentric cable is used to carry the high tension current. The boxes, whether for junctions or transformers, are made entirely of cast-iron, the lids being screwed down and rendered watertight and airtight by means of India-rubber rings. It is claimed that the whole system of pipes and boxes is metalically continuous and entirely watertight. In addition to these precautions, air is forced through the mains by a Roots blower; before being

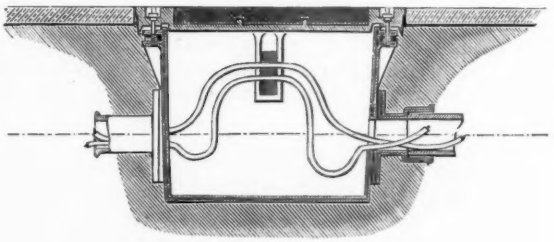


Fig. 1.—Section of Junction Box.

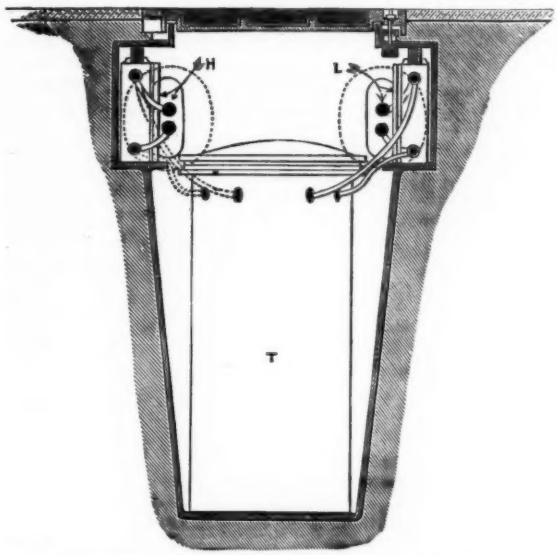
pumped through the pipes, it passes over chloride of calcium, which extracts whatever moisture there happens to exist. Connections to consumers is usually made by means of India-rubber covered cables led through wrought-iron pipes, the ends of which are screwed into the junction box. Fig. 1 shows the construction and the arrangement of mains in this box. It should be mentioned that all joints in the cast-iron pipes which carry the mains, are run in with lead.

The Sub-Stations.

After all, the sub-stations at Scarborough are not sub-stations: we think street transformers is the better term, for the only difference between this outdoor and house transforming is that, in the first case, the converters are simply placed in a hole in the ground; naturally they are on a larger scale than those used on consumers' premises, and they transform for a fairly large area, but there is no pretence of making chambers underground, such as one would have expected. Of course the output of electric current would not justify the erection of proper sub-stations, so that, after all, the use of street transformers is perhaps the only satisfactory means of distributing electricity over the different localities of Scarborough. It is needless to draw comparisons between this method and that of placing converters on the consumers' premises. The objections to street transformers are, that water may get into the box; another is, that they may be difficult to examine. We do not think that either of these objections can be urged against the method adopted at Scarborough. The writer carefully examined one of the transformer boxes and there was not the slightest sign of dampness. Every possible precaution has been taken to prevent water getting into the boxes, the blowing arrangement is no doubt effective over the greater part of the system; but the construction of the box itself is the surest protection against the entry of water.

The sub-stations are designed to hold a 50 H.P. transformer, but smaller transformers are used at present. Fig. 2 will give an idea of the arrangement, which, by the way, has been patented by Messrs. Parsons. These sub-station boxes are connected together by two lines of cast-iron pipes, one set carrying the high-tension mains and the other carrying

the low-pressure cables. It will be seen from the drawing that recesses are provided in the sides of the boxes to contain the high and low tension fuses; these compartments are provided with separate water-tight covers. The transformers are of Messrs. Parsons's design. The small ones are placed in round iron cases, the larger ones being placed in square



H, High tension mains and fuses; L, Low tension mains and fuses; T, Transformer.

Fig. 2.—Transformer in Sub-stations.

iron boxes filled with oil. Each transformer is fitted with a Cardew earthing device. Schallenberger meters are used for consumers.

At the present moment about 70 customers are being supplied, the total number of lamps connected approaching 5,000. It must be mentioned that practically the whole of these lamps have been connected since September of last year.

The average price per unit will be about 6d., the charges for consumption, not exceeding 200 meters, being 6½d. When the consumption exceeds 800 units, the price comes to about 5¾d. Special discounts are also allowed. According to the agreement with the Corporation, it is provided that the maximum price of electricity shall not exceed, for private customers, 7d. per Board of Trade unit, and for street lighting, 6d. per unit. The price may be further reduced after an accumulated dividend of 8 per cent. has been paid to the shareholders.

The erecting work has been done very rapidly, for it was not till February, 1893, that a start was made, and a supply of electricity was available on September 1st.

The expenditure was somewhat as follows :—

Land	£1,625
Buildings and cost of constructing condensing pond	3,341
Machinery and boilers	7,934
Mains, including laying	5,445
Transformers, meters, tools, &c.	1,595
	£19,940

The erection of the buildings has been carried out under the supervision of Messrs. Hall & Tugwell, architects, Scarborough.

Messrs. Parsons & Co., of Newcastle, have equipped the station, and the mains and the sub-station laid under the direct superintendence of Mr. G. S. Peck, the resident engineer to the company, the excavating and making good the pavement being performed by the Corporation. Mr. A. A. Campbell Swinton, the consulting engineer and managing director, has supervised the whole of the work. To those two gentlemen our thanks are due for their courtesy during our recent visit.

Derby Electrical Exhibition.—There is to be an electrical exhibition held at Derby. The Electric Lighting Committee have power to spend £200 upon it.

COMPETITION v. FAIRNESS.

The effect, for good or otherwise, of competition is a subject upon which there are differences of opinion. Some manufacturers consider anything and everything fair in the way of competition, provided they can keep outside the precincts of illegal interference. The stagnant condition of trade during the past two years, and the consequent difficulty experienced in securing business to keep factories and shops in operation, has led to unreasonable and unhealthy cutting of prices, while, at the same time, we are inclined to think it has also exerted a lowering influence, to say the least of it, upon the morals of some business men. To legitimately push one's manufactures to the extent of one's power is both justifiable and commendable, but to clutch at every possible opportunity of bringing into disrepute the work carried out by a competitive firm for the purpose, if possible, of killing them off, can hardly be considered the fairest method of doing business. Such a course is, however, repeatedly followed by commercial travellers in their tours in London and the provinces, and has been the cause of more than one action for libel or slander. Manufacturers should be very cautious as to what use they make of injurious information coming to their ears regarding their competitors' wares.

A well known London firm of wiring and installation contractors have for some time past issued lists of some of the installation work done by them. These lists have naturally fallen into the hands of competitors, and a certain over-enterprising manufacturing company have apparently seized the opportunity of drawing out a list of questions which they have had printed, and are sending to each of the proprietors of the establishments fitted up with installations by the firm in question. When we observe that some of the questions request the names of the makers of the various plant employed, and also ask whether the work has given satisfaction, we cannot but have serious misgivings as to the intention of the circulator in the event of the information being given. Several people have absolutely declined to answer the questions, and it is to be hoped that the rest will do likewise, even should they be not quite satisfied with the execution of the work or the plant installed.

CORRESPONDENCE.

The Theryc-Oblasser Accumulator.

Your article on the Theryc-Oblasser accumulator, and the report of Dr. Fleming thereon, of the 9th inst., has been brought to my notice. You state that your criticism is given with reserve until you have before you ample proof and particulars to enable you to give a complete opinion. I trust that you will accept my reply, and insert it in the next issue of your paper, the independence and high authority of which are well known.

I have sent to you a specimen of our plates, because I believe that an inspection of it alone will at once cause you to modify your first impression, as it has in other cases immediately changed the opinion of eminent electricians in France and England.

It is evident from your article that you have only a written description of the plate before you, and had not seen the accumulator.

Our accumulators constitute an absolute innovation in connection with the application of paste, and the employment of the envelope has nothing in common with similar applications to protect the oxide from falling. The latter was an entirely secondary matter with us; however, it has been successfully realised.

Our envelope is continuous, and is made of celluloid, closed on all sides, and pierced with numerous small holes, and its main feature is to constitute a monolith with the agglomerate of oxide by special means, as described in our patent. The grid of lead and antimony, reduced to the proportion strictly necessary to serve only as a conductor of current, is entirely surrounded, and is placed in the centre of the above agglomerate, and is thus protected from the attacks of the acid, and from sulphation by electrolysis, and it assures a perfect contact and long life.

The chief characteristic of our accumulator is that the whole constitutes a monolith, composed of the oxide supported by an elastic material unattackable by acid, such as our envelope of absolutely pure celluloid. This celluloid envelope, by its complete elasticity, follows the expansion and contraction of the monolith when charged or discharged.

The above explanations and description show clearly the manifold advantages gained in consequence of the above disposition of parts.

The practical capacity of our accumulator, when well formed, is very superior to 7·46 ampères per lb., as stated by Dr. Fleming, who was experimenting with new and imperfectly formed plates. It attains, in practical industrial use, 11·5 ampère-hours per lb., and La Compagnie Industrielle des Accumulateurs Electriques Liege, who have bought, and are working our Belgian patent, state that it has even exceeded 13 ampères per lb., at a rate of discharge of ·45 ampères, with accumulators properly formed.

The accumulators tested by Dr. Fleming had only been sufficiently formed to enable them to stand the transport from Belgium, in order that the doctor might satisfy himself of the rapidity of the formation. The details and figures in the report clearly show this state of non-formation. Dr. Fleming's remark that he found a "very insignificant amount of the active material disintegrated in the form of mud in the bottom of the cell," is explained as follows :—When the plates are first made, the small holes in the celluloid are filled with oxide dust, and in formation this oxide shrinks and falls off.

We find this mode of cleaning is preferable to using a brush, but after the plate is properly formed no oxide whatever escapes.

You will easily see that the normal efficiency of the 11-plate battery (referred to in Dr. Fleming's report), could not give 11 ampères per lb., because the plates were not formed, and did not receive a charge superior to 9·8 ampères. This normal capacity of 11·5 ampères exceeds considerably the capacity of certain accumulators made for special purposes that you mention, but which you admit are fragile, whilst our accumulator is characterised by its strength. Its solidity and its life have survived the most severe tests that have ever been given to any accumulator.

For 15 months the Paris, Lyons, and Mediterranean Railway, and the two laboratories of the French Navy, have submitted our accumulators to the most violent and decisive tests in forcing the discharge to 4, 5, and even 6 ampères per lb., without showing any indications of deterioration. The result of the tests made for 15 months have been declared to be very remarkable by the technical committee who have advised its adoption, and have given large and important orders on behalf of these two great Administrations.

The experiments of the Paris, Lyons and Marseilles Railway Company have been conducted by a commission of six electrical engineers selected by that company, and their report is couched in the most favourable terms, and the above company has adopted it, not only for the lighting of their trains, but for locomotive traction. Its installation for lighting purposes has already been made, and it is fitted in 50 of their carriages.

The Paris, Lyons and Marseilles Railway Company has caused to be published in *La Revue Generale des Chemins de fer* of March, 1893, the official report and the plans of these installations, with our accumulator.

Further, the same company has been constructing for six months in its workshops at Oullins, near Lyons, an electric locomotive patented by them, which is intended to be driven by our accumulators. This locomotive will be of 700 nominal H.P. but working up to 1,100 H.P. They purpose running at a constant speed of 68 miles per hour on the level, and 50 miles per hour on the gradient, on the line from Paris to Marseilles and Nice.

As our accumulators will work at the considerable rate of 2¾ to 3 ampères per lb., the company do not fear to submit it to continuous strain, nor are they asking the manufacturers to give any guarantee as to its durability, for they are convinced by their experiences (of over 15 months' duration) of its solidity and its capability of enduring such forced discharges.

The Commission of Engineers of the Paris, Lyons and Marseilles Railway Company examined the state of the accumulators after their long experiments, and opened many of the plates for the purpose, and it has been found—first, that the interior grids were in perfect condition, and that after they had cleared off the agglomerate of oxide, they could not find any trace of sulphation or alteration, and the grids were of the same weight as new grids. Secondly, that the celluloid envelopes were in a good state of preservation, and still promised a long and good service.

Lastly.—The trials for tramway traction, which have been made at Liege, demonstrate the exceptional power of our accumulator. A battery of 1,320 lbs. of electrodes (2,090 lbs. liquid and boxes included) has sufficed to work an electric tramcar of 7 tons weight for a journey of upwards of 25½ miles. A regular service is about to follow these remarkable experiments.

I dare to hope, Sirs, that the decisive experiments which have been followed by the definite adoption of our accumulators by two administrations so important as those of the French Navy and the Paris, Lyons and Mediterranean Railway Company, constitute a patronage and a guarantee sufficiently to cause you to study further the advantages, and the great progress which our invention realises, and to cause you to give attention to the experiments which are now being made in London. I am convinced that you will also admit the advantages which I have mentioned, and which I will now sum up as follows :—

1. *Its Great Solidity.*—There is no possibility of fall of active material, or of short circuit.

2. *The Interior Grid.*—This is secured from the direct contact and the action of the acidulated liquid.

3. The effective and industrial output of 11 to 12 ampères per pound at the rate of ·45, stopping the discharge at 1·8 volts. The realisation of an electrical horse-power capacity in 48 lbs. of total weight, and in a volume of one-third of a cubic foot, that is 2½ to 6 times less than with the best accumulators known.

4. It is specially remarkable by the very small diminution of its useful capacity as the rate of discharge is increased; whilst existing accumulators which give 100 ampères at a rate of discharge of ·45 ampères per lb., give only 50 useful ampères, if one increases the rate of discharge three times, or up to 1·35 (according to the printed statements of their manufacturers). Our accumulator, under the same conditions, maintains an efficiency superior to 80 useful ampères, under fall of potential down to 1·8. The lowering of the useful capacity is less than 10 per cent. for each increase of ·45 ampère per lb. This unprecedented quality is of the greatest importance for traction purposes.

5. It sustains, without inconvenience or damage, a constant rate of discharge, considered up till now impracticable, of 2·25 to 2·75 ampères per lb., which can be increased, in case of need, to 4 ampères per lb.

6. Its nominal rate of charge is from 1·36 ampères to 1·80 ampères per lb., that is, four to six times more rapid than that of the best known accumulators for the same amount of ampère-hours stored.

In case of pressure, one is able to increase this rate without any other inconvenience than a waste of the charging current.

7. In case of need, one can continue the rate of discharge much under the fall of potential of 1·8 volts, the limit to which all the above calculations were made.

It is possible to utilise the voltage down to the fall of potential of 1·2 volts without damage, which is the case in other accumulators.* This constitutes a further notable advantage for traction purposes or for navigation.

8. The power of holding its charge in our accumulator, when charged, and put on one side for many months, is remarkable; the loss of capacity is extremely slight.

A powerful government has made for 12 months' trials, which have been considered decisive, for the use of our accumulators for a certain military purpose, for use in fortresses, batteries for search lights, for electric search light cars, driven by one horse, and to give night sight for firing guns.

Such, Sirs, are the results which you can prove, and of which you will, I hope, appreciate the value from the point of view of applications considered until to-day unattainable by accumulators.

Ch. Theryc.

Bristol Hotel, Burlington Gardens.

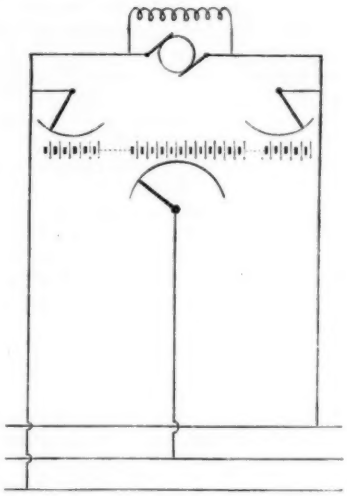
* [This is evidently intended to read "which is not the case," &c., &c. Mr. Theryc has certainly made out a very

good case for his batteries, and we trust all that he claims for them may be realised, for we are just as desirous, as we ever have been, to see the accumulator industry progress by leaps and bounds. Probably we may shortly have an opportunity of personally ascertaining how far Mr. Theryc has outdistanced rival inventors.—Eds. Elec. Rev.]

Balancing in a Three-Wire Station with only One Machine Running.

Without commenting upon Mr. Gibson's proposal, I should like to offer another suggestion for the above, which, though doubtless open to many objections, certainly has simplicity to recommend it.

The generators are shunt wound and connected, as shown, across the outside mains. The cells are capable of giving an E.M.F. at least equal to that of the dynamo, and are joined to outside mains through the side switches, and to middle wire through the middle switch. It is thus possible to move these



three contacts up and down the cells as required. Should the left side, for instance, become overloaded, we move the middle switch to the right of the centre point, and thus increase voltage on left side. The ampères of charging or discharging can also be varied by adjusting the side switches without affecting the external circuit.

It is, of course, only possible to alter *total* E.M.F. by inserting shunt resistance in dynamo field, but it should be possible to place an excess of volts on either side at will, and that would seem to be all that is required.

I should be much obliged if any of your readers would point out any further objections to this method.

Kenelm Edgcumbe.

Chelmsford, *March 13th.*

I notice Mr. Gibson's reply to my letter in your last issue, asking for some figures to go by. In the case at Burnley, the resistance of the feeders is such that every 100 ampères through either of the outside wires means, roughly, a loss of 1 volt, and every 100 ampères through the balancing wire a loss of 3 volts. So that, taking the case quoted of 400 ampères in one circuit, and 300 ampères in the other, it will be seen that in order to maintain 105 volts on each circuit at the feeding point, it is necessary to have 112 volts on one side at the generating station, and 105 volts on the other—a difference of 7 volts. The question is, "How is this difference in pressure to be produced with the proposed arrangement of two armatures running on the same shaft, and between the same pair of magnets?"

The loss owing to the armature resistance is so small, that we are told we may discard it, and the reaction of the armatures on the field magnets will affect both armatures alike, so that it will not enter into the question.

Mr. Gibson appears to suggest that the difficulty is to be overcome by varying the number of cells in parallel with each armature, and by throwing over the station lights and motors. But the former will only vary the amount of work given out, or absorbed by, the batteries; and changing over the station lights will only tend to equalise the load on each armature, but neither arrangement can do anything towards producing a difference in the pressures of the two armatures. If any satisfactory method could be discovered of producing the required difference of pressure in the two armatures, the scheme would be of interest.

F. Thursfield.

Burnley, *March 13th*, 1893.

Synchronising Alternators.

I am rather disappointed to learn from a letter in your last issue that there is still any difficulty or uncertainty experienced in synchronising alternators. During the past 15 months we have synchronised at this station on about 1,000 occasions without the slightest semblance of a hitch, and have not found it necessary to use any special fuses or switches, our only apparatus being a synchronising lamp, with a voltmeter in circuit as a stand-by, in case of the lamp filament giving out from any cause.

The whole operation of putting a light machine in parallel with a loaded one takes, as a rule, 1½ minutes from time of starting up the spare plant, and if simply changing over from one machine to another, half a minute more suffices to take the load and disconnect the machine to be shut down, the changes being effected without any perceptible variation in voltage.

In my opinion the ease of synchronising depends very much upon the type of governor fitted to the engine, and if this be reliable in working, and admits of the adjustment being instantly and widely varied, I believe that alternators can be put in parallel as quickly as circumstances can demand.

With such governors on our slow speed Corliss engines, coupled by ropes to the alternators, the station engineers synchronise without any anxiety as to the result, whatever the conditions of the load may be.

M. Ruddle.

The Heilmann Locomotive.

Our little discussion anent the above has travelled rather outside the field of electricity into that of railroad topics, pure and simple. I must therefore leave in your hands entirely the publication or not of this further letter, as I would not like to ask for space in your pages except when dealing with electrical matters. If you or your leader writer will follow me into the pages of one or other of the railway journals, I shall be ready and pleased to argue still further in a more suitable sphere.

With reference to the points in your leader last week, I will content myself now with commenting upon the following:—First, the Heilmann locomotive steam engine is not merely a high pressure motor, but is compounded. Although, of course, it is not condensing, I am not sure but that it might be so worked, with a little ingenuity. Air cooling would be conceivable, even if the use of condensation water be impossible. If ordinary compound steam locomotives effect so great an economy over the simple type, why is it that we do not see them adopted on a greater scale in this country? Perhaps it may be for the same reason that railway authorities will not adopt electric traction—the change is too great; but I doubt it. More likely the cause may be that the saving in coal is nearly counterbalanced by the greater wear and tear, cost of renewals, and repairs generally entailed by the use of more complicated machinery in a compound locomotive.

Secondly, I have never seen or heard of a steam locomotive, on ordinary railroads, doing average work, which contented itself with a diet of only 17 lbs. of coal per mile—if that is your mean per train mile. If you had said 37 lbs. per train mile, it would have been nearer the mark, but I would object very strongly to compare performances according to the rather senseless criterion of a "train mile." This standard has no real meaning: a train may be any weight, and a mile of line may be of any character. It is time that coal consumption was brought down to a comparison between amounts used per ton-mile, or, perhaps, passenger-ton-mile,

on the straight level, with allowances for curves and grades. For this reason, I gave as an average consumption of coal in steam locomotives from 4 to 8 lbs. per horse-power hour, which, at any rate, allows comparison with stationary engines, and is based on a number of averages from good working practice.

Thirdly, if you consider the plan adopted by Mr. Heilmann so radically wrong (let me again add that I do not myself maintain any faith in it, when we have no figures or working results as yet), I shall look forward with interest to your criticisms upon the somewhat similar arrangement of double conversion proposed by Mr. Ward Leonard for the use of alternating currents, in which he employs a stationary alternating generator, passing current into a line wire from which a synchronous motor on the locomotive is operated so as to drive a continuous current generator on the same spindle. Current from the latter is taken to the motors on the locomotive axles.

I am writing hurriedly, or would try to deal further with this.

Frank B. Lea.

Electric Lighting of Steamships.

Your articles on electric lighting on board ship are undoubtedly calculated to do good. May I suggest that due recognition should be given to the persistency with which Captain A. Froud, R.N.R., has collected evidence and brought the matter forward in the first place. I thoroughly agree with your and his remarks on this subject. Only those who have had to do with ships under weigh can understand the varying conditions under which leads are continually placed. Lead covered cables are undeniably the best. The great difficulty of these is the frequency with which the joints of the lead covering go wrong, even when it has been made by the most skilful workman. It would appear that to make the joint solid is a difficult matter. This is very regrettable, as the slightest defect in the lead covering makes it worse than the absence of covering would be. A defective covering will retain any water that may get in. When the leads pass through bulkheads or partitions of any sort, great care is necessary to minimise the setting up of any vibration in the cable from the vibration of the ship, as even the slightest will soon chafe through the covering. It would be a great advantage were it possible to lead wires along amidships, where there would be less danger of their vibrating on frame angle pieces and such like, and they would be much more easy of access.

Ship's lighting is a matter which requires the most careful attention and foresight at the time of installation, if much after expense and trouble would be avoided.

The double wire is not only the safest, but the surest to keep in good order, when once installed.

D. Wilson Barker.

With reference to Mr. W. C. Martin's letter in your last week's issue, in regard to the above subject, I should like to pass a few remarks. I am sorry to say that Mr. Martin advocates wood casing for engine rooms, instead of condemning it, as anyone who has had experience in working aboard steamships ought to know that an engine room is anything but dry—being generally full of steam, the result is that everything in and around is perfectly saturated with moisture. I have been repairing some of the said installations that Mr. Martin speaks of, and I have found that the casing was yellow pine, and not teak, as stated to be, in a wretched condition, having got twisted by the heat and saturated by water and steam, the iron screws that fix the casing to the bulkhead rusted and immovable, and the wire—not in one particular part, but in several different parts of the ship—to be in a rotten condition. Now, as to the exposed parts of a ship. Mr. Martin suggests galvanised iron pipes, which is but proper; but I do not think it right or practical to fix them alongside steam pipes. But let Mr. Martin try iron pipes for engine room and stokeholds, and I have no doubt that better results will follow.

Argos.

In your last week's issue, Mr. R. Kennedy seems to have no confidence whatever in the jointers and wiremen of the period, and I think Jamieson and Munro's "Pocket-book for Electrical Engineers" should be mentioned here. But coming from theory to practice, Mr. Kennedy ought to know that there are thousands of good jointers to be got who can make an insulated joint which will stand low or high tension, and even the acidulated water test, without being vulcanised, and I can assure Mr. Kennedy that there are some jointers employed by a certain firm of electrical engineers, whose joints, if he saw them, could not help but pronouncing the *ne plus ultra* in the art of jointing. With reference to fuses in backblocks, which Mr. Kennedy seems to advocate, I think that this most dangerous and troublesome practice ought to be stopped, especially on board tank steamers, a good number of this class having been fitted by Messrs. Andrews & Kennedy, and in places where petroleum gas may accumulate, feeling heartily sorry for the man whoever attempts to repair one of those installations. I quite agree with Mr. Tidd that the *weakest* point in a *double wire* installation is the *lamp-holder*, of which we have numerous types; for the simple reason that in a pendant fitted to the deck, the moisture and sweat accumulates behind the backblock, and drops through the centre screw-holes and fitting into the lamp-holder, and corrodes the holders and lamp terminals as well. Therefore every block and screws which fix it to the deck should get a good layer of white lead before being fitted.

Should the deck be leaky, which nuisance occurs at times, the water will run through the fitting and holder, and fill the globe. To avoid this I have designed a special insulator, made of soft vulcanised rubber, with two holes through it, to fit the contact spring terminals and cavities to suit type of holder, which is slid over the contacts before the bayonet socket and rim is fitted. By fixing the lamp into the holder, this rubber insulator is compressed, and shuts off the holder from the fitting perfectly damp and watertight.

Leon H. Cline.

With reference to Mr. Kennedy's letter in last week's issue, allow me to say that I had no intention of being personal; but Mr. Kennedy, having advocated a system which experience has shown to be a very inferior one, I felt it a duty to challenge the value of his opinions. If such articles are to appear in your paper, both sides of the question should be dealt with fairly upon their respective merits, and as Mr. Kennedy pretends to be an authority upon this subject, it is a pity he cannot defend the efficacy of his system instead of attempting to cast unworthy insinuations.

W. C. Martin.

Glasgow, *March 12th*, 1894.

Correction.—In the letter on this subject in our issue of February 23rd, signed L. Muitt, an error occurred in the signature, which should be L. Newitt.

J. Wilson.—Owing to the great pressure upon our columns during the past few weeks, we are compelled to hold over your letter on "The Capacity of Leyden Jars Joined in Cascade or Series" until next week, when we will reply to same, as you request.—Eds. Elec. Rev.

We have received another letter regarding the Theryc-Oblasser battery, but are compelled to hold it over until next week owing to its late arrival.

Cork Proposed Tramways.—The Judicial Committee of the Privy Council, sitting at Dublin last week, sanctioned a system of tramways through the City of Cork, with the right to use electricity as a motive power. The scheme comprised three sections, two of which were sanctioned. The second of the sections was objected to by the Board of Trade, on the ground that the street was too narrow, and was not sanctioned by the Privy Council. The following is the scheme as originally proposed, viz.:—(1) A line from the Great Southern and Western Railway Station to Muskerry Railway Station; (2) a line from Patrick Street through Marlborough Street to the Cork and Passage Station; and (3) a line from the end of King Street to Blackpool.

LEGAL.

Muirhead v. Commercial Cable Company.

(*Continued from page* **291.**)

Third Day.—Friday.

Mr. Mockridge, operator for the **Western Union Telegraph** Company, said he had had 20 years of the Atlantic service, and considered the plaintiffs' 1880 patent a novel and important combination.

Mr. Taylor, electrical engineer, and one of the plaintiffs in this action, said he had been working the duplex system for many years. He began to work with Messrs. Muirhead in 1875. In that year they began to plan the scheme they now had in use, and in 1876 they got it in actual working for submarine telegraphy. The state of common knowledge in 1876 to 1880 was absolutely *nil* with regard to duplexing long cables, until he and his partners did it. In 1876 and 1877 the great difficulty was to get a balance so that the sending signals did not upset the receiving instrument. Ultimately, as the result of his experiments, he was of opinion that the double block system gave accuracy as well as speed. He had tried many plans to procure perfect balance in cables. He knew that resistances in the arms of the bridge meant retardation of speed. In 1876 and 1877 they did not dream that what they accomplished in the patent of 1880 was possible.

Cross-examined by Sir R. Webster: Mr. Stearns was also working with witness and Mr. Alexander Muirhead in this matter from 1872 onwards. In the American patent specification the balance of resistance might be got without the rheostat. Speaking of duplex systems worked on the bridge, there was some system of adjustment of resistance of the two arms of the bridge.

Was not the principal way in which resistance was taken out and retardation avoided by putting in the split condenser?—Yes. You could not dispense with high resistance without those condensers.

Take the specification of 1876: "Sometimes I use two condensers, or a set of condensers, one set being placed between the end of one branch of the bridge of the cable, and the other set between the other branch of the bridge and the artificial line. By this latter arrangement, which I shall call the 'bridge condensers,' it is found that the resistance may be greatly reduced in the arms of the bridge." Was not the reduction of resistance in consequence of putting the condensers into the bridge arms?—Yes.

Was not putting the bridge condensers into the bridge arms the means by which you were to reduce the resistance in the American patent?—Yes.

Was not that the invention in 1876?—Yes. No one would have dreamed of working the plan shown in fig. 2 of that patent without some means of adjustment of the resistance of the bridge; but there was not the slightest mention of any adjustment of the resistance. In order to make the instruments effective for maintaining the balance, there must be some adjustment of the resistance.

Re-examined by Mr. Bousfield: Before we got this final plan of adjusting resistances we tried dozens of plans. The plan in the 1880 we first practically put into work in 1884. We have not found a better plan since. The defendants are, I believe, still using the "double block" system. The knowledge we had in 1876 did not help us much to make the plan of 1880.

Mr. Justice Kennedy: What was there you did not know in 1876 that you knew in 1880?

Witness: We were unable in 1876 to overcome the difficulties of maintaining balances.

In your view, does success depend upon the combining together of the different elements in this particular way of the patent of 1880?—Quite so; if you remove any element you lose your success at once. Rheostats, bridge, condensers and sending condensers were known by 1880, but we did not know in 1876 the best way to arrange them. They were never arranged in this particular way before 1880.

Prof. Bottomley, examined by Mr. Finlay, said: I am a Fellow of the Royal Society, a Professor of Glasgow University, and have had very large experience in electrical matters. Since 1870 I have taken charge of all Lord Kelvin's submarine experimental work. I have examined the patents of 1880. The combination consists of a battery, a key, an adjustment rheostat, sending condensers each in a bridge wire, the cable or true line connected with one side, and the artificial line with the other, and a receiving instrument and its condenser.

Could any one of these elements be eliminated, retaining the advantage of the combination?—No, not one. There are two main advantages in this method, obtaining a balance, and preventing the sending instrument interfering with the receiving instrument at the same end, and the other advantage is the legibility of signals. This combination has never, to my knowledge, been made before 1880. In my judgment the invention was new and valuable. I do not find in the patent of 1876 any anticipation of the 1880 part.

Cross-examined by Sir R. Webster: Mr. Stearns had made no appreciable improvement in duplexing. Before 1880 Mr. Smith had attempted duplexing with the Marseilles and Malta cable. In my opinion the invention of putting the condensers into the bridge line was a good invention, and it was the step which made it possible to do away with high resistances. The rheostat would be of no use without the bridge condensers. In my opinion a rheostat means a continuously operating resistance balance. In the resistance adjustment boxes in use before 1876, the taking out of the peg would break the circuit.

Mr. Alexander Muirhead, the grantee of the American patent of 1880, said he had never used the combination shown in that patent before 1880, and it was a very useful and valuable combination.

Cross-examined: The 1876 patent showed condensers in the bridge arms. The ordinary way of bringing back slight changes was then adjusting the bridge arms.

Re-examined by Mr. Finlay: He was over in America, and was himself the applicant for the patent.

Were not the 1876 and 1877 patents before the examiner?—Yes. Both those patents were before the examiner when this 1880 patent was examined for its grant.

What was practically the difference of working, as you worked under the 1876 patent and under the 1880 patent?—Under the 1876 patent I do not think I ever got more than 40 per cent. increase of speed.

By that you mean 40 per cent. improvement on the simplex result?—On the simplex result. Under the 1880 patent on the Commercial Cable Company's system between England and Canada, on a special trial of speed, we attained an increase of at least 95 per cent.

Is that over the simplex?—Yes.

Mr. Moulton: Of course I do not know with what device he worked the 1876.

Mr. Finlay: Under any procedure under the 1876 patent you did not get more than you have told us?—I do not think I ever got more than 40 per cent., probably 30.

Mr. John Muirhead, one of the plaintiffs, examined by Mr. Finlay, said the patent of 1876 was granted to him, and the patent of 1877 was granted to him jointly with Mr. Alexander Muirhead. He was a party to the agreement with the defendant company.

Under the 1876 patent, did you ever use combination shown in fig. 3 of 1880 patent?—Never.

Did you know that such a combination was possible?—No.

Was it ever used before 1880?—Not to my knowledge.

If it had been, do you think you would have heard of it?—Most certainly.

You have heard what your brother said as to difference of results obtained by working under the 1876 patent as compared with the 1880 patent?—Yes.

Is that correct?—Perfectly correct.

Cross-examined by Mr. Moulton: Did you ever work the double block system under the 1876 patent?—Not that I can remember.

So that the results you are referring to under the 1880 patent are results due to the double block system?—To the arrangement as shown here—the double block system.

Is that the first time the double block system had ever been worked?—Yes.

In re-examination by Mr. Finlay, Witness said he never worked the double block under the 1876 patent. He never knew of the combination of the double block with the other things that are claimed before 1880.

Dr. Hopkinson, F.R.S., stated, in answer to Mr. Bousfield, that he had for the last 15 years given great attention to matters of engineering. In the course of practical work he had made many experiments with a bridge system somewhat similar to that then used in duplexing. He had worked a bridge system very analogous to the bridge system which is used in duplexing, both for determining resistance capacities, self-inductions, and every possible or almost every possible quantity that can be determined in that way experimentally.

Take the 1880 patent, Dr. Hopkinson. It has been suggested by my learned friend that it was an obvious thing to take a rheostat and to put it in that particular place in order to get the required balance?—Yes.

Do you think that any electrician could tell without experiment and research what would be the effect practically in that combination of taking a rheostat and placing it in that particular place?—He certainly could not. He could not tell. With the knowledge which was conveyed in the 1876 patent, it would not be possible for an electrician to say, without experiment, whether he could obtain a complete and perfect balance by the means shown in fig. 1. With figs. 2 and 3 as shown, no electrician would have been able in 1880 to have told you certainly whether he would obtain a balance by the means shown in figs. 2 and 3 without proper and careful experiments.

Could you, without experiment, find out what would be the effect of using the rheostat in that way?—No, you would not be able to ascertain whether you could get a perfectly satisfactory balance in that way, or whether you could not.

As far as you know in 1880, was it a new thing to use a rheostat in combination with condensers, and without any other resistances in that way?—I believe it was.

Do you find anything in the 1876 patent which would have enabled you, as an electrician, to arrive at the combinations or results which have been referred to as being in the 1880 patent?—As to results, I have not experience enough to say whether you could get equal, inferior, or better results by the one rather than by the other. There is nothing in the 1876 patent which would lead you to the same combination that you have shown in the 1880 patent.

My learned friend has put it that the various elements of that combination are old: that a rheostat had been used before?—Yes.

Bridge condensers had been used before; receiving condensers had been used before?—Yes.

In your view, what do the results of that 1880 patent depend upon? Do they flow independently from those different elements?—They flow from the actual combination there used. In the 1880 patent there is no new element at all. Every element there described was known long before that date; as far as I know, they were never used in the same combination.

Cross-examined by Mr. Moulton: Now, Dr. Hopkinson, duplexing of landlines was known in 1876, was it not?—I believe, well known.

In the duplexing of land lines, I believe, you had to have from time to time varying adjustments arising from differences of temperature?—Yes; and also from the effects of leakage upon the line.

Therefore, in working a duplex system, you had, ordinarily, adjustments of the resistance in the bridge arms?—I cannot say whether that was the usual way or not.

In land lines, was it the usual way to vary the bridge arms by means of a rheostat joined up at the apex?—I do not know.

If you suppose that a rheostat at the apex was used for adjusting, how would fig. 2 of 1876 differ from figs. 2 and 3 of 1880?—In the last you have a condenser in the receiving instrument. In fig. 2 of the earlier patent you have not. I do not lay any stress upon that, because I find in the other figs. of 1876 patent that that condenser is present. Then you have a total absence of resistance in the bridge arms, and only a very small adjustable resistance in the rheostat.

There is a resistance in the bridge arms, due to the resistance in the rheostat?—Undoubtedly. That may not be in both sides of the bridge arms in some circumstances of adjustment.

Now, in fig. 2, there is a resistance in the bridge arms on the other side?—Yes; I may just point out—I do not know whether anything turns upon it—it is on the other side of the condenser in that case.

This closed the evidence for the plaintiffs.

Mr. Finlay submitted to his lordship that the defendants must show that the patent of 1876 was identically the same process or combination as shown in the patent of 1880. They could not attack the validity of the 1880 patent. If they did, in the face of the evidence that had been adduced, he submitted that they would fail. But that evidence had come in only incidentally, because they were estopped from saying that the patent for the combination of 1880 was not a good patent. They had to make out, first, that in the patent of 1876 was described the same combination for which the patent of 1880 was granted.

Sir R. Webster opened the defendants' case. He said: Now, my Lord, there are two questions in this case, one of fact the other of law. The contract is to be regarded as being an English contract. As to what a licensee can do, I believe there is no difference in the law of England and the law of America in this matter. We are not attacking validity in any shape or form. The United States allow an inventor to patent at any time, provided that the invention has not been brought into public use in the United States for more than two years before. This is no attack whatever upon the validity of the United States patent. It is a contention which we are entitled to raise, that by operation of law the United States patent has come to an end. What is the position of a licensee? It is settled by the law of England in the case of Crossley *v.* Dickinson in the House of Lords, and of Clarke *v.* Adie in the Court of Appeal. The licensee may not dispute the validity of a patent. He may not say that the specification is not sufficient; that the subject-matter is not good, or that it was not a new and useful invention. He may say he does not infringe; and, in order to show whether he infringes or not, he is not only entitled, but bound to tell the Court what he says was the existing state of public knowledge at the time of the grant. As Lord Blackburn put it, you have to consider "the existing state of knowledge for the purpose of showing what was the construction of the patent which would make it good, and not the construction of the patent which would make it bad." That being considered by the Court, a licensee is entitled to prove two things—one, that he does not bring himself within the terms or boundaries of the patent; the other, that the term of the patent has expired. With reference to the position in which we stand, I therefore contend that a licensee under such a license deed as this, and, in fact, within the very words of the license deed, is surely entitled to show that the period during which a patent lasts has expired. It does not mean the term of the patent, because that is a fixed term—it does not mean of necessity the number of years specified, because that *is* specified upon the face of the grant; it is the period during which the patent lasts, so that other people cannot use it without infringing or paying a royalty, and I, the licensee, am bound to pay a royalty during that period. The simple case is this—aye or no, is the patent of 1880 for an invention substantially the same as was patented in 1876? It is not a question of whether there is more in 1876 or more in 1880. The American law is distinct upon that—I may, perhaps, have to refer to the cases—that if the patentee claims for an invention an American patent, which invention is substantially the same as that which is included in an earlier English patent, the patent lapses at the expiration of the earliest English or foreign patent; and it is for that reason that your Lordship has heard no discussion from us as to the technicalities or differences of figs. 4 and 5 which are the subject of claim 2 of the American patent.

The hearing was adjourned until Saturday.

Fourth Day (Saturday).

Sir R. Webster, continuing, said: My case is that when the 1876 patent is examined, the system which was patented in 1880 is in all its particulars there described, and I go so far as saying that a skilled workman must, by reading the specification of 1876, have made the combination patented in 1880. There is not a single witness for the plaintiffs who can pretend, or has pretended, that the rheostat was not made the resistance adjustment. People who have been working duplex telegraphy for years will tell you that an increase of resistance for the purpose of improving your sending current does not disturb the current on your receiver. There is no magic in putting the rheostat at the apex of the bridge; the balance may be restored even though the one arm may be slightly increased. In 1876 Mr. Alexander Muirhead and Mr. John Muirhead knew a great deal too much to allow it to be possible for the construction to be put upon this 1876 specification which is essential for their present action. There are two conditions of a specification. One is that it must not claim that which is common knowledge, and the other is that it must contain sufficient information to enable a practical workman to carry it into effect. It does not lie in the mouth of the patentee to say, "You are to construe my specification as not giving sufficient directions to enable you to carry it out." It would be absurd. No license would be possible if my learned friend was entitled to say, "You are to read this specification as not containing sufficient directions to carry it into effect." It must be read in the same way as against a licensee as against an infringer. It must be read as a complete and sufficient specification. The first broad commentary against this most excellent invention, which it is the object of Mr. Finlay to belittle to-day, is that there was no detail of machinery at all shown. To electricians, the words, "adjustable resistance," "bridge," and "high resistances," are self-contained. With the existing state of knowledge, it is ridiculous for Mr. Muirhead's counsel to contend that the specification did not contain sufficient information. What is there in the 1880 patent which was not in the 1876 patent? There can be but one answer—"rheostat." It is absolutely impossible for a competent electrician to give but the one answer, that the rheostat put in that place is the only thing which is not shown in the 1876 patent. And I say that a competent workman using the 1876 plan must have put in a rheostat. It is quite clear that in 1880 the patentee picking out what was best in his invention of 1876, and taking it to America picks out the condensers on the bridge. No electrician will come and suggest that the use of the rheostat *per se* made any difference at all in the great advantages that were claimed. In the 1876 specification you do not find the slightest description of the kind of condensers to be used. If you put condensers in you get rid of your high resistances. In cases of difficulty you are told "certain additional adjustments may be employed." The broad admission of every witness for the plaintiff is, that fig. 2 of 1876 cannot be worked without adjustment from the bridge. You must have some kind of adjustment. What would be used? Here we come to that which has been studiously kept out of view by the witnesses for the plaintiffs—common knowledge with regard to adjustment of bridges. A great deal of unnecessary mystery has been introduced into this case by suggesting that the working of submarine lines was different to landlines. The most common way of balancing bridges, in order to get the proper proportion of resistance, was by the rheostat at the end of the two bridges joined. There is no magic about this, so far as submarine telegraphy is concerned, and the common thing to do in 1876 was to put the rheostat there. In the 1876 patent there was no direction given to substitute anything for the rheostat at the bridge apex. It is palpably absurd to suggest that the rheostat, which was known by everybody as common knowledge, is to be treated as fundamental to this combination, and that it was excluded in 1876. I have not any Lord Kelvins to call as witnesses, because there is only one Lord Kelvin; but I will call men who have done as much work as any persons whose names can be mentioned.

Prof. Andrew Jamieson, examined by Mr. Moulton, said he was professor of electricity and engineering at the Glasgow and West of Scotland Technical College, and a member of various learned societies. For four years he was the electrician abroad of the Eastern Telegraph Company, which had the largest system of submarine cables in the world. My acquaintance with telegraphy, continued the witness, goes back to 1872, when I was assistant to Prof. Sir William Thomson, and at the end of 1873 I was sent out to Brazil to the laying and maintaining of that system. In the autumn of 1876 Mr. John Pender secured my services, and authorised me to make myself fully acquainted with duplex telegraphy in every sense, and to proceed at once to Marseilles and Malta in order to right the duplex signals. On my arrival at Marseilles, the system that I found put up there was what was known as Muirhead's duplex system. From that time until now I have been acquainted with what has been done in duplexing. In those early years, 1872 and 1876, duplexing was done on landlines, but submarine cables introduced special difficulties. At that time landlines were duplexed according to the bridge method as well as the differential.

Now in duplexing by the bridge method, whether by landlines or submarine cables, how do you get the balance?—In setting up such a system, the engineer in charge must arrange so as to get a balance. In 1876 on landlines this rheostat was used. When I arrived at Marseilles in 1876, I found an apparatus like the one in Court, and it was only for the work of adjustment. It does not make any difference when you use a box like this, or a rheostat as shown in plaintiffs' diagram. It is not of the slightest practical effect whether you make the adjustment by the rheostat at the apex of the bridge arms or on one or other of the arms. That is a fact well known to electricians. It does not make any practical difference whether your adjusting instrument is connected at the apex, or to either arm. In 1876 a competent electrician, looking at fig. of the 1876 patent, would suppose that there were forms of adjustable variable resistances. Looking at fig. 2 he would suppose there were the same adjustable variable resistances. These would be absolutely necessary, in order to make those plans work.

Do you think a competent electrician at that date would require any specific statements that those were adjustable variable resistances, to make him acquainted with that fact?—None.

Now take the 1880 specification. In your opinion, to a competent electrician, is there any more told you in fig. 1 of 1880 patent than was told in fig. 1 of 1876?—All that is told in 1880, over and above that of 1876, is the receiving condenser and the rheostat, as depicted at the end of the line.

As a matter of substance, is there anything beyond what the diagrams in the 1876 patent told you?—No.

Mr. Justice Kennedy: What about the receiving condenser?

Witness: Well, my lord, the receiving condenser was always used in duplexing in cables of any length, and a competent electrician would take that for granted.

Turning back for one moment to 1876, is there a description of the use of the receiving condenser to which you have referred?—Yes.

In 1880 does the receiving condenser intervene between the one part of the receiving instrument and the junction of the cable with the condenser?—It does. The difference between the figs. 1 and 2 in the 1880 specification is the introduction of condensers in the arms of the bridge.

Do you find that indicated in the 1876?—I do.

Do you find the specification of 1880 gives any other information excepting that?—No.

Supposing the rheostat were put in the arm instead of at the apex of the bridge. In your opinion, would it be substantially the same combination?—The same.

Is it of any importance to keep the same sum of resistances in the two bridge arms constant?—It is not; and, as a matter of fact, it is not done.

Who does the adjustment so as to keep the balance?—The receiving clerk.

Mr. Justice Kennedy: How does he do it?

Witness: He does it by altering this rheostat while observing his recorder; or, should there be no rheostat, he does it by unpegging or plugging more or less resistance in one arm of the bridge.

In each case, he does it either by putting in or taking out wire in the circuit?—Certainly.

When you are balancing, are you sending or receiving, or do you do the balancing before you set to work?—When you are balancing you are not receiving.

Lord Kelvin suggested that it was very important to keep the sum of the resistances of the arms constant. Do you agree?—It produces no practical effect to keep the arms $r + r_1$ constant.

Cross-examined by Mr. Finlay: It was part of your duty to become familiar with the patents passed in duplexing, from 1876 to the present time?—Yes; and I have discharged that duty to the best of my ability.

You were acquainted with the patent of 1876 when it came out. Did you adopt Muirhead's system?—Yes, on the Malta to Alexandria cable.

Did you eliminate all resistances from the arms of the bridge?—Yes; all resistances entirely from the arms of the bridge.

Did you have a condenser in each arm of the bridge?—I did.

And a condenser on the receiving circuit?—Yes.

And a rheostat at the junction?—No. I say there was no necessity to have a rheostat.

Then to the extent of not having a rheostat, you did not reproduce the 1880 patent?—To that extent I did not.

What arrangement did you have for adjusting the balance?—Adjusting the condensers on the one side or the other.

How?—You can adjust your balance perfectly by Mr. Herbert Taylor's method, by adjusting the value of the amount of capacity in the condensers in either arm of the bridge by the ordinary condensers.

Where is that process that you adopted at Malta described?—In Mr. Benjamin Smith's patent, No. 47, January 5th, 1876. I was with the inventor at the time.

But, Prof. Jamieson, you have not there got condensers on the receiving circuit?—I say that that was a matter of common knowledge.

No, no. You told me that you had adopted fig. 3 of Muirhead's 1880 patent, and I asked you where that was described; you refer me to this patent of Mr. Smith's. In this description and drawing there is no condenser shown on the receiving circuit?—No, that is a mere appendage of the receiver. There is no condenser shown in the receiving circuit on the drawing.

Mr. Moulton: There is no battery shown either. (Laughter.)

Mr. Finlay: I dare say not, but the most elementary knowledge would show that was wanted. That is hardly a fair analogy.

In this drawing you have no condenser in the receiving circuit, but you have resistance boxes in the cable at one end, and also in the artificial cable?—Yes.

Can you point out in the letterpress any reference to having a condenser in the receiving circuit?—I am not aware that there is such a reference.

In that arrangement you got the balance by means of the resistance in the cable?—No.

Then what are these resistance boxes for in the cable?—Not for the means of adjusting the balance in that sense. The condensers at the end of the bridge arms are to enable you to adjust the balance in the bridge arms.

Then they were put there and adjustable for the purpose of obtaining the first balance? Then the device that was there used for adjusting the balance from time to time, if the cable varied under the various conditions from the artificial cable—means for effecting the adjustment from time to time was by means of dealing with the condensers?—Yes.

Do you mean to tell me that is the same arrangement as fig. 3 of Muirhead's 1880 patent?—Yes. I mean to say it contains the essential features of that patent.

Do you mean to tell me, sir, it is identical?—Not every iota.

The effect of using resistance boxes in the cable for obtaining a balance is to reduce the speed?—Certainly not.

To secure a balance you use a resistance box in the cable?—Yes.

But does not the use of that have the undesirable effect of reducing the speed?—Yes.

Do you mean to state that by the use of that method on a cable between Ireland and America the same improvement could be obtained that was got by Muirhead's 1880 patent?—I do.

Is not the difficulty in a long cable to secure speed combined with balance?—That may be.

How is it that this valuable invention of yours remained hid. Why did not you and Prof. Smith patent in 1876 a device which would have yielded results equal to those yielded by Muirhead's 1880 patent?—When I reported to Sir James Anderson the success of Benjamin Smith's and my experiments in this way, and particularly the success of our balance, he said to me, "Don't say anything about it; I am interested in Muirhead's duplex."

And so this valuable invention of yours was suppressed?—It was suppressed. (Laughter.)

By a conspiracy?—I do not say by a conspiracy. (Renewed laughter.)

Now with relation to this famous patent of Benjamin Smith of 1876. Was the means for getting adjustment in the arms of the bridge and removing temporary disturbances by means of condensers?—Not entirely; we found we could adjust by the condensers.

What were the means for obtaining temporary adjustment of the balance; had you earth current, or anything of that kind?—There is nothing in the specification with regard to obtaining a temporary balance; it was so well known to electricians. You will not find a word in the patent about that.

Do you tell the Court that the means of obtaining a temporary balance was so well known to electricians in 1876 that it could be considered matter of common knowledge?—Yes.

How long was this process in actual working?—A day or two.

And did it disappear after a day or two?—Sir James Anderson again thought Muirhead's was better.

It has never been heard of before until to-day?—We have talked about it.

Is Smith's patent now in use?—Not as a permanent installation. But Smith's patent was substantially the same as Muirhead's patent of 1880. Any competent electrician knew how to put a condenser into a receiving circuit. The condenser on the receiving circuit, patented by Mr. Muirhead and shown in his book subsequent to 1876, was left out before, because he thought it so much a matter of common knowledge that he did not think it worth his while to put it in. Muirhead's system was also used on the Porthcurno and Lisbon cable in 1879. There is no reference to any condenser on the receiving circuit in the patent, because we never did anything else in practice.

Was not that system on the Lisbon and Porthcurno cable abandoned on account of diminution of speed, and Mr. Muirhead's system adopted in its place?—Not to my knowledge.

Do you maintain that in using a condenser you would naturally put it at the apex of the bridge, as in the 1880 patent?—Certainly.

Re-examined: I say that the position of the rheostat at the apex was a common one in 1876

The Court adjourned until Monday.

(To be continued.)

The Edison-Bell Phonograph Corporation v. The London Phonograph Company.

In the Chancery Division of the High Court of Justice, on Friday, the 9th inst., before Mr. Justice North, Mr. Moulton, Q.C., moved for an interim injunction to restrain the defendants from continuing to infringe certain letters patent.

The learned counsel said his Lordship would remember that these letters patent were for improvements in phonographs, which had been established by trial before Mr. Justice Wright, in the Queen's Bench Division. The original affidavits set forth that the defendant was using a phonograph infringing the letters patent, and the affidavit of the defendant in answer put forward that it was impossible for the plaintiffs' witnesses, who spoke to infringement, to have seen the machines.

Mr. Justice North: What is the date of the patent, and when was it established?

Mr. Moulton said the patent was November 28th, 1889. It had twice come into Court. In one case the defendant did not appear, but the patent was established, and judgment was obtained against him. That was before Mr. Justice Day. Subsequently it was tried before Mr. Justice Wright in January of this year. That learned judge supported the patent and granted an injunction, so the plaintiffs were in a position of having established their right at law. The action was against Smith and Young. The patent had several claims, all of which were supported by the learned judge. The consequence of the inspection had been that the plaintiffs' witnesses, who were very well acquainted with phonographs—Mr. Cole, the practical manager of the plaintiff's business, and Mr. Swinburne—were satisfied that these phonographs infringed, and now they found the defendants' phonographs still infringed, though they had been altered. They had been altered so as to remove parts dealt with specially by the claims of the patent that had been supported. The affidavit of the defendants was eminently unsatisfactory on that point. He (Mr. Moulton) thought his Lordship would come to the conclusion that what had happened was that after the date of the judgment, the defendants altered, to a certain extent, though not completely, their instrument, in order to make it appear as though they did not infringe, and they had not told his Lordship, but had tried to represent it as though these instruments had been in this condition all the time. The evidence the plaintiffs had of the state in which the instruments were when they first saw them, coupled with the evidence as to this last examination, would, he thought, convince his Lordship that was what had occurred, and that the defendants had tried to conceal from the Court the fact that they were in possession of infringing instruments in a different condition from that in which they now were at the time when they were shown for inspection to the plaintiffs' experts on Monday last.

At this juncture it was discovered that the defendants had not had time to reply to the affidavits of the plaintiffs, and the hearing of the motion stood over until Friday, the 17th inst.

William Selfer v. the City of London Electric Lighting Company, Limited.

This case came before Mr. Justice Kekewich, sitting in the Chancery Division, on Friday in last week, Mr. Warmington, Q.C., on behalf of the lessee of the Waterman's Arms, at Bankside, Southwark, asking for an injunction until the trial of the action to restrain the defendant company from so continuing their works as to injure the plaintiff's premises and injure him in his business.

Mr. Renshaw, Q.C. (interposing), said he appeared for the

fendants in this and another action attached to the Court of Mr. Justice Chitty; and Mr. Badcock said he appeared for the landlords of the premises, Messrs. Meux's Brewery Company, who were cited in the case as plaintiffs, and he asked that the application should stand over pending their perusal of the affidavits.

Mr. Warmington said they had not yet seen any affidavit on the other side. The matter was very urgent, and if there was to be a conflict it was desirable there should be no unnecessary delay.

Mr. Renshaw said he thought there must be a transfer in respect to one of the two actions.

His Lordship said, without that, he could hear the motion and then it could be transferred, as, indeed, it must be, if the case went for trial.

Mr. Renshaw thought the case might very well be taken once for all.

In the result the application was ordered to stand over for a week.

Hall *v.* Charlesworth.

This case came on at Manchester last week. Mr. Joseph P. Hall and Mr. S. Charlesworth carried on business in partnership as electrical engineers in Oldham. The defendant, Mr. Charlesworth, also carried on a separate business in the same town as a printer's engineer. The partnership was dissolved in December, 1893, the plaintiff, Mr. Hall, taking over the business. Subsequent to the dissolution letters addressed to the partnership firm came into the hands of the defendant, Mr. Charlesworth, who retained them. The plaintiff claimed that these letters were his, in accordance with the terms on which he took over the business, and he now applied to the Court for an injunction to restrain the defendant from retaining such letters and making use of the information in them.

Mr. Roby appeared for the plaintiff.

Mr. Maberly, who represented the defendant, argued that the purchase of the business by the plaintiff did not include the goodwill, and therefore could not give him a right to letters received after the dissolution.

The Vice-Chancellor granted an order restraining the defendant till the trial of the action from retaining, opening, or reading any letters, telegrams, parcels, or communications addressed to the partnership firm, and from supplying any orders contained in such letters. The plaintiff was to give an undertaking as to damages, to hand over to the defendant any letters intended for him personally, and in the meantime to preserve all communications addressed to the old firm, and to keep an account of all profits obtained from orders so received.

Wayleaves.

An interesting case was tried at the Court of Record of the Salford Hundred last month, which throws a very important light upon the legal aspect of the wayleave question of telephone wires. The New Telephone Company had connected up certain of their subscribers to their telephone exchange in Manchester, and in order to do so, had made attachments to the premises occupied by these subscribers as tenants. For these attachments, and also for some other prospective ones, negotiations and correspondence had taken place between the landlord of the premises and the New Telephone Company; but as these had not arrived at any exactly definite solution, the landlord brought an action against the New Telephone Company for trespass, and also for certain payments in respect of "wayleave" for each of the attachments as agreed upon.

The case was tried at the Court of Record in Manchester, on February 16th last, before Mr. H. G. Shee, Q.C., Judge of the Salford Hundred, who, in summing up, remarked that before dealing with the question of the agreement, he might just as well make one or two observations on other parts of the case, which are no longer in controversy, in consequence of the view he took of the law. We reproduce the exact words of the learned judge in summing up, as they must be considered of importance:—

"One of the claims made by the plaintiff was that there had been a trespass on his premises, inasmuch as the defendants went on to the premises for the purpose of putting up wires. The view I take of that, with regard to premises let entirely to one tenant, from floor to roof—business premises let to a business person for business purposes—is that, there being no damage done to the premises, the tenant would be entitled to put telephone wires into his office; and any person who put them in would be doing it for the tenant, and there could be no action for trespass against the defendant company for doing that work, any more than there could be against the tenant himself for putting up in his office what was reasonably necessary for carrying on his business. That is what I hold with regard to a building let wholly to one tenant; and it seems to me that the same principle applies equally to a case in which a building is let to a number of tenants. It was contended by the plaintiff's counsel that it was only the offices that were let, and that the landlord reserved to himself the staircase and the roof. But I am afraid there would not be much use of an office unless there was a staircase to go to it, and therefore the tenant, or anybody acting for him, who only used the staircase for reasonable business purposes, would not be in any sense committing a trespass. The plaintiff's counsel, quite early in the case, felt that he had difficulty with regard to the staircase, but then, he said, with regard to the roof I have a much stronger case. I think the same reasoning applies with regard to the roof as with regard to the staircase. A building must have a roof, and certainly the tenant who was immediately under the roof would be entitled to use it, and also to use the staircase for this purpose. I think if it would be an ordinary way of making a business use of the whole of the premises, to use the roof on behalf of each individual tenant for the purpose of telephone wires, that is a right and proper thing to be done, and there can be no more trespass with regard to the roof than with regard to the staircase. If it would be reasonable to put up wires connected with the roof in order that they might come into the ground floor, I think that would be a reasonable use of the premises, and that anybody acting for the tenant in doing so would not be committing a trespass. Therefore, as I have to decide the matter, I do decide that there has been no trespass committed by the defendants."

The question of agreement was a matter left to the jury to decide upon, and they gave their verdict in favour of the defendants, who therefore gained the day upon both points.

The difficulties of obtaining "wayleaves" now-a-days is very great, and many people are deprived of the use of a telephone through want of the necessary wayleave along the route. The present ruling as regards the law of the case simplifies the matter so far as the tenant is concerned who requires a telephone fixed and connected, but it does not affect the right of attachment to a building for "through" wires. The wayleaves of both landlord and tenant are necessary in this case.

Wise *v.* The Metropolitan Electric Supply Company.

In the Chancery Division on Tuesday and Wednesday, Mr. Justice Stirling had this case before him. The action was brought by certain occupiers and leaseholders in Manchester Street, Manchester Square, where one of the company's central stations is erected, to obtain an injunction against the defendants on the ground of a nuisance caused by vibration. Mr. Graham Hastings, Q.C., and Mr. Beaumont appeared for the plaintiffs, while Sir R. Webster, Q.C., Mr. Phipson Beale, Q.C., and Mr. Vernon Smith, represented the defendants.

Mr. Graham Hastings, in opening the case, said the object of the injunction sought for was to prevent the continuance of the nuisance created by the defendants' works. The nuisance was so material that the vibration consequent upon it made it intolerable to the occupants of the houses, or some of them, to dwell there. It seemed to be a most mysterious thing. Sometimes the vibration affected the top of the house, sometimes the bottom. According to the view of one gentleman, it arose from the fact that that part of the City of London was built on the bed of the river which once flowed over the locality, and the soil was of that character that it conveyed the vibration produced by the engines. It was said that this could be got rid of, but the learned counsel contended otherwise. The real defence, he contended, was that they had been doing all they could to abate the nuisance. The plaintiffs were Mr. Wise, residing at 43, and Mr. Henry Grant, at No. 17. Mr. Hastings proceeded to dilate upon the effects of the nuisance complained of, and quoted instances where families were shaken in their beds, and prevented from sleeping, clocks stopped, and to touch certain objects in the house caused the fingers to tingle, and alarmed the residents.

Prof. Silvanus Thompson, in giving evidence, produced a phonograph, which was placed on the bench before his Lordship to give a repetition of the vibration and jarring caused by the working of the defendants' machinery in premises adjoining Marylebone Station. The phonograph had been set in various rooms in the houses affected, and witness produced it in support of his statement of the results of his examination of them. On the instrument being put in position on the ledge of the witness-box, his Lordship quitted his seat, and, walking to the end of his "bench," held the tubes to his ears. Apparently satisfied, his Lordship, after listening for a minute or two, returned to his seat and made, as usual, a short note of the "evidence."

Mr. Wise, one of the plaintiffs, having given evidence, Sir Richard Webster opened the case, and on Wednesday evening the further hearing was adjourned.

BOOKS RECEIVED.

Traité de Télégraphie Electrique. Par H. Thomas. Published by Baudry et Cie., 15, Rue des Saints-Pères, Paris.

Annual Report of the Board of Regents of the Smithsonian Institution to July, 1891.

Transactions of the American Society of Mechanical Engineers, Vol. XIV., 1893.

La Téléphonie, Historique, Technique, &c. Par Emile Pierard. Published by Charles Desoer, Rue Gérardrie, Liége.

A Short Practical Treatise on Municipal Electric Lighting. By Francis H. Medhurst. Keliher & Co., 33, King William Street, E.C.

BUSINESS NOTICES, &c.

The Universal Electrical Directory (J. A. Berly's) for 1894.—Published by H. Alabaster, Gatehouse & Co., 22, Paternoster Row, London, E.C. This directory comprises the names of 18,414 different individuals and firms, is divided into four sections, namely, British, Continental, American and Colonial, each of these being sub-divided into alphabetical and classified sections. There are about 800 pages consisting entirely of directory matter, making the book the fullest, as it is the oldest, electrical directory in the world. The price of the work is 4s., post free.

The Phonopore Company, Limited.—This company has issued a circular relating to the further improvements it has lately made in utilising existing telegraph wires and in doubling their carrying capacity. To meet the requirements of several of the railway companies, it has taken up the question of working a single needle instrument by the phonopore system. This the company has accomplished; and as nearly all telegraphists read by the sound from the needle, it can now offer to railway companies a new sounder, worked by a handle similar to a single needle instrument, by which an entire circuit can be duplicated. This instrument (or a phonopore telephone for speaking, with a special bell call on the same wire) can also be attached to the block, bell or train staff wires without any interference with their working. If the needle instrument is preferred to this new sounder, this can be applied to existing wires, but two wires are required for working the needle. A mixed circuit can be formed of the two systems, sounders and needles. Phonopore telephones can be attached to ordinary telegraph and block wires, and conversation can be carried on distinctly in spite of any ordinary induction. The company is now in a position to supply the following systems, all worked on the existing telegraph wires:—The improved phonopore telegraph, the needle phonopore, the new phonopore sounder, and phonopore telephones. On several occasions, when a wire has broken or become defective, and the ordinary telegraph in consequence became unworkable, it is stated that the phonopore telegraph remained undisturbed and continued to work satisfactorily although on the defective wire.

Electrical Clock.—A new electrical time clock has lately been invented by Messrs. Allam & Holt, of Manchester, which they claim to be economical for use on railways, large works, hotels, &c. It is composed of three ordinary dial wheels and a disc fastened on a 6-tooth pinion driving the same dial wheels. The disc has 10 pins at equal distances apart, ½ inch long parallel with pinion on outside edge of disc. A pair of small coils and armature with a hook fastened at the end of armature stem are connected up to an ordinary clock, making contact on a wheel which revolves once a minute, thereby drawing the armature, and the hook catching one of the pins in the disc, causes the minute hand to move one minute, the hour hand, of course, moving proportionately. The hook on the armature is so arranged that when the current is off and the armature falls back, the hook swings into position for lifting the next pin in disc. What Messrs. Allam and Holt claim in favour of this invention is, its cheapness and simplicity, requiring no winding nor regulating, having neither spring nor pendulum. They simply want connecting up to a master clock, which alone would require winding. It will be seen from the above that any number of these clocks can be connected up to one master clock any distance apart.

Anti-Sulphuric Enamel.—We have received from Messrs. Griffiths Brothers & Co., of Bermondsey, a new circular giving particulars of this enamel. This material was first invented at the suggestion of Messrs. Crompton & Co., Limited, to meet the need of a protection for metal and wood work from the destructive action of the fumes and spray in battery rooms. The list of stations given in the circular where it has been employed comprises nearly all those in the United Kingdom in which accumulators are used. Judging from the testimonials contained in the circular, there is no longer any need to fear damage to buildings or fittings by the use of storage batteries, as the means of preventing it is simple and inexpensive. Being a good insulator, and drying quickly, this enamel is also serviceable for coating any articles that require a fine finish, and when applied to metal work it retains great flexibility. Messrs. Griffiths also give in this list particulars of shellac, varnishes, &c., manufactured especially for the electrical trade. This material has been used in the accumulator rooms of the electric lighting station at Aberdeen to protect the wood and metal work from the action of the acid fumes and spray thrown off by the batteries.

Electric Lighting of York Law Courts.—At a recent meeting of the City Council, it was stated that the cost of the electric lighting of the Law Courts was as follows:—Total cost of the gas engine and fixing same, £202 11s. 2d.; dynamo and everything connected with it, nil, the committee having made an arrangement with the owners; cost of wiring and all other electric lighting apparatus in the new Law Courts building, £1,279 1s. 1d.; total capital expended, £1,481 12s. 3d. Also total cost for one year, 1893: In wages of attendants of engine, &c., £140 15s. 8½d.; electric engineer's repairing, &c., nil; oil, waste, £23 4s. 11d.; gas for engine, £147 7s. 6d.; water for engine, £21 12s. 6d.; new lamps and materials for renewals of electric light apparatus, £29 2s. 5d.; repairs to engine, dynamo, lamp, &c., £41 7s. 1½d.; cost of gas lighting for one year (say 1892) in old police office and fire-engine station, before business was removed to the Law Courts, £35 12s. 8d.

Electrical Cooking.—Messrs. Crompton & Co., Limited, gave an exhibition of electrical heating and cooking appliances at the Sanitary Institute, on Friday last, before the Duchess of Albany and a large company of ladies. Mr. H. J. Dowsing, who had charge of the exhibition, showed electric ovens, hot plates, radiators, foot warmers, &c., at work. Her Royal Highness took great interest in the apparatus, and was particularly struck with the perfect cleanliness of the cooking arrangements. The convenient system of regulating the heat of the ovens was particularly noticed and the possibility of warming rooms without vitiating the atmosphere, by means of electric radiators, gave great satisfaction. At the close of the exhibition Her Royal Highness expressed herself as delighted with what she had seen, and personally thanked the demonstrator for the explanations he had given as to the working of the apparatus.

Preston Scientific Society.—The members of this society on 3rd inst. visited the works of the National Electric Supply Company, in that town.

Hodges & Todd.—This firm, who for the last few years have manufactured electrical measuring instruments of various descriptions, have, owing to the large increase in their business, taken additional works at 30—42b, Hampstead Road, where for some time they have been busy putting down fresh plant, &c., in order to meet the demands for their specialities. In fitting up their works they have had in view the requirements of central station engineers for supplying switchboards, switches, &c., as well as the instruments, and they can now turn out this class of work very rapidly. Electricity is the motive power by which their machinery is driven, the whole being controlled from the main switchboard in the testing-room. The offices still remain at 82, Turnmill Street, E.C., where all communications should be addressed.

Bankruptcy.—Mr. Louis Swaby applied at the Brentford Bankruptcy Court for his discharge. He pleaded that he became insolvent by acting faithfully to the shareholders of a company of which he was a director. He contended that he was "shamefully and maliciously persecuted and defrauded for honestly carrying out his duties as a director of the Maxim-Weston Electric Light Company, in protecting the shareholders, by publicly denouncing a balance-sheet and report which had been sent to the shareholders, bearing his name against his protest." Judge Bagshawe, after listening to various statements, suspended the discharge for two years from December 22nd, 1893.

Mill Lighting.—Messrs. Bennett & Druce, Preston, have received instructions from Messrs. Horrockses, Crewdson and Co., Limited, to instal a complete system of electric light in their new cotton spinning mill in course of erection. The plant will consist of three 500-light dynamos, two of which will be be driven by the main engine, and a third off a special vertical engine. An interchangeable system of wiring has been devised by Mr. Druce, so that complete failure of the light will be an impossibility. About 900 lamps will be installed.

Stafford Electric Lighting.—The Local Government Board have sanctioned the application of the council for power to borrow £20,000 for electric lighting purposes, which has to be repaid within 20 years. Tenders for the erection of central station buildings are shortly to be advertised for, but in the matter of engines, boilers, and dynamos, it has been decided not to invite tenders, not from the electrical trade generally, but from a few well-known firms whose names were recommended by the Electric Lighting Committee.

Search Lights on the Manchester Ship Canal.—Complete search light plants for the night navigation of the Manchester Ship Canal are being supplied and equipped by Messrs. Baxendale and Co. Captain McLaren of the ss. *Grampus*, who recently gave the projectors an experimental trial, reported that every satisfaction was given, the passage over the canal being performed in little over 5 hours.

Telegraphic Communication—British North Borneo.—The Eastern Extension Telegraph Company have just agreed to connect Borneo with Labuan by a branch cable, and the directors of the British North Borneo Company have decided to connect the capital of their territory, Sandakan, by telegraph and road across country, a distance of over 200 miles. The work will be completed within a few months.

Scarborough Central Station.—Mr. Bernard Drake has, at the request of the Corporation, reported upon the work carried out by the Scarborough Electric Lighting Company. He considers the central station, which we describe elsewhere in this issue, is well designed, and the plant throughout well suited to the requirements of the town. The supply during his visit was both regular and efficient.

The Electric Light at Malton.—A number of people the other day witnessed the re-installation of the electric light at the works of the Malton Farmers' Manure and Trading Company, Limited. The works were partly destroyed by fire three months ago, and everything has now been put in order. The electric light installation has again been put in by Messrs. Parr & Gillies, of Haggerston, London.

Chatham and Electric Tramways.—At the last meeting of the Chatham Town Council the Mayor gave notice that at the next meeting he should propose that the Electric Lighting Company be approached to see whether they are prepared to supply the motive power for an electric tramway from the Luton Arch along the New Road to the top of Star Hill.

Liverpool Lighting.—At last week's meeting of the City Council a letter was read from the Liverpool Trades Council, enclosing a resolution passed by that body suggesting that, in view of the present exorbitant price of gas, the City Council consider the possibility of utilising the tidal force for the generation of electricity for the lighting of Liverpool.

Plymouth and Electric Lighting.—A correspondent of the local papers, who has a smattering of knowledge regarding electric lighting work at present being carried out in this country, in a lengthy communication tries to arouse the enthusiasm of his fellow-citizens in favour of the adoption of electric lighting for Plymouth. He thinks the local authorities very sleepy in the matter.

Newington, Priddle & Company, Limited.—The creditors and shareholders of this company met on Thursday, March 15th, at Carey Street, W.C., before Mr. Warley, assistant official receiver. The case was left in the hands of the official receiver to be wound up by that official in his capacity of liquidator, assisted by a committee of inspection to be hereafter selected.

Incandescent Lamps.—We have received from Messrs. Barclay & Son of Regent Street, W., a circular announcing their appointment as sole agents for the United Kingdom for incandescent lamps manufactured by Messrs. Pulsford, Triquet et Cie. The circular also gives information regarding prices, &c.

Electric Light at Dundee.—It has been ascertained that the cost of laying pipes and cables for the electric lighting of the Central Police Station would be about £528. Relaying pavement would cost extra, as would, of course, the wiring and fittings work inside the buildings.

Electric Lighting of Manchester Athenæum.—The Manchester Athenæum authorities are considering the question of lighting the building with electricity, and have commissioned Mr. S. V. Clirehugh, of Messrs. Wilson & Clirehugh, to prepare plans and specifications for carrying out the necessary work.

Bristol Electric Lighting.—The Electrical Committee last week decided to supply electric light at 4d. per unit between the hour before sunset and midnight. Customers whose bills range from £50 to £100 will have 5 per cent. rebate; £100 to £250, 10 per cent.; and larger amounts reductions up to 20 per cent. are promised.

Electric Lighting at Bradford.—At the meeting of the Bradford Town Council on Tuesday, the Gas and Electricity Committee asked for confirmation of a resolution to supply electricity at 3½d. per unit for use as motive power. The committee are also re-laying their principal mains on the "three-wire" system.

Salford Electric Lighting.—The *Gas Engineer* in a recent report states that the whole of the contracts for the electric lighting installation, amounting to £25,500, have been let, three of them being placed with local firms.

School Lighting.—The Manchester Edison-Swan Company have the order to fit up an installation of 230 16-C.P. lamps and a 12 H.P. gas engine at the Leigh Technical School and Public Library.

Blackpool Electric Lighting.—Last Wednesday the Local Government Board held an inquiry as to the application of the Town Council for power to borrow £24,000 for the extension of the electricity works and other sums for various purposes.

For Sale.—We have received from Messrs. Wheatley Kirk, Price & Goulty a list of the electric lighting and other plant which they have for sale. A large number of arc lamps, dynamos, search lights, and arc and incandescent installations appear in the list.

Canterbury Electric Lighting.—The Brush Electrical Engineering Company have been granted an extension of time to June 30th, 1894, for forming the Canterbury Electricity Supply Company.

Acton and Electric Lighting.—The Local Board are about to enter into an agreement with Mr. Medhurst regarding the supply of electricity to the district. Under this agreement the lighting by electricity will cost no more than the gas lighting.

Aberdeen Shop Electric Lighting—Aberdeen shopkeepers are going in for electric lighting with a rush. Within the past ten days quite a number of shops have had the current switched on.

Electric Lighting of the Victoria Embankment.—The London County Council on Tuesday decided, by a large majority, that it was undesirable that the lamp-columns be placed in the centre of the roadway.

Wolverhampton Electric Lighting.—The Local Government Board have sanctioned the borrowing of £30,000 by the Town Council, for the electric lighting scheme.

Hawick and Electric Lighting.—A member of the Town Council intends to move that the electric light be introduced into the town.

Killarney Electric Lighting.—The Commissioners have signed a contract with the Killarney Electric Light Company to supply the town with electricity.

Aberystwyth Electric Lighting.—The location of the public arc lamps was decided last week, 17 will be placed upon the promenade.

Ambleside and Electric Lighting.—The Local Board have refused the application of Messrs. R. H Fell & Son, who desired to lay an electric cable to Low Wood Hotel.

Electric Lighting of Prescot.—The electric lighting of the town is now considered satisfactory.

Mill Lighting.—Messrs. Sands, Wilson & Co., of Wensleydale Mills, Batley, have adopted the electric light.

CONTRACTS OPEN AND CLOSED.

OPEN.

Glasgow.—The general manager of the Glasgow Corporation Tramways invites parties in a position to contract for the electric lighting of about 240 tramcars for one or more years, to communicate with him at once. Address, Mr. John Young, City Chambers, Glasgow.

Stafford.—March 19th. The Corporation are prepared to receive tenders for the erection of buildings for the new central electric supply station. Conditions of contract, &c., may be obtained on application to Mr. J. F. Bell, engineer, Gasworks, Stafford.

NOTES.

Oldham Electric Lighting.—It was expected that the electric light would be turned on this week.

The Royal Society.—The following paper was down for reading yesterday:—"Experiments on a Fundamental Question in Electro-Optics: Reduction of Relative Retardations to Absolute," by Dr. Kerr, F.R.S.

Exeter Electric Lighting.—The question of lighting the headquarter police station by electricity is being considered. The estimated cost of the installation is about £42.

Edinburgh Electric Lighting.—The Electric Lighting Committee have recommended the appointment of Mr. E. W. Monkhouse (of the Westminster Electric Supply Corporation, Eccleston Place station), as electrician to the city.

Another Use for Electricity.—At the Royal Wilts Bacon Factory, instead of the old-fashioned mode of branding pigs with a heavy heated iron, an electric brand, easy to handle, is used.

Brighton Electric Lighting.—A Local Government inquiry was held last week into an application of the Corporation to borrow a sum of money for electric lighting purposes. The scheme is to buy the goodwill of the Brighton and Hove Electric Lighting Company.

Electricity in the Production of Silver.—The New York *Times*, in an article on the cost of producing silver, considers that electricity may be looked to, to further cheapen the cost of mining, thus enabling America to produce silver profitably, not only at 60 cents per ounce, but even at 50 cents or 45 cents.

Transformation of Electric Currents.—In our comments on Prof. Silvanus Thompson's lecture at the Royal Institution, which appeared in our issue of 2nd inst., an error occurred at the end of the last paragraph but one. For "was at a disadvantage on a circuit of 133 ~," read, "was at a disadvantage on a circuit of 83 ~," the latter figure being the frequency of the Deptford supply.

Northern Society of Electrical Engineers.—The following have been elected members of this Society:—Geo. Broughall, of Manchester Edison-Swan Company; T. B. C. Nuttall, of Siemens Bros., London; A. Oughterson, of W. T. Glover & Co., Manchester; F. A. Pocklington, of Callendar's Bitumen Company, Liverpool; R. P. Wilson, of Wilson and Clirehugh, London. It has been arranged to hold a second smoking concert on Monday, April 2nd.

Appointment.—Mr. C. H. Wordingham, Assoc. M.Inst.C.E., has been appointed chief engineer to the Manchester Corporation Electric Works, on the recommendation of the Electric Lighting Committee. Mr. Wordingham superintended the carrying out of the several contracts for the establishment of the central stations at Manchester and Whitehaven, on behalf of Dr. Hopkinson, and has been running the Manchester Station during the last three months.

Gas v. Electricity in London.—A meeting, protesting against the charges of the Gas Light and Coke Company, was held last week at Victoria Park. A resolution was unanimously passed expressive of the opinion that a Parliamentary Committee should be appointed to consider the present condition of the London gas supply. The seconder of this resolution remarked that the only way "to meet the gas company, if they persisted in the present charges, was to introduce the electric light, and he hoped the Bethnal Green Vestry would take the matter in hand."

In response to the request of the Strand Board of Works, Mr. A. Ventris, surveyor, submitted a report on the cost of gas and electric lighting. He showed that the total expenditure on the revised lighting by gas in the district was £6,408 3s. The cost of electric light, he estimated, could not be less than £11,842 10s. It was decided to continue gas lighting.

Electrician Drowned.—Mr. J. E. W. Imrie, an electrician of Newmarket, was last week drowned while out wild-fowl shooting on the Norfolk coast.

Bristol Electric Lighting.—The Hinckley Local Board have deducted £11 from the account of the electric lighting company, in consequence of lights being out on 22 nights, at 10s. per night.

Abergavenny Electric Lighting.—Tenders for a report on the advisability and cost of an electric lighting installation were recently invited. Those received ranged from 20 to 100 guineas. That of Mr. Manville, for 35 guineas, including expenses, was accepted.

Portsmouth Electric Lighting.—The Electric Lighting Committee have been authorised to appoint such officers and workmen as are found to be required in connection with the electric light in Portsmouth, which, it is expected, will be started in April.

A Capital Advertisement.—A South Wales firm recently agreed to light Swansea Parish Church by electricity. The lamps were fitted up, but, much to the displeasure of the worshippers, it was discovered last Sunday that the globes bore in bold lettering the name of the firm referred to. This has, of course, since been remedied. It is quite bad enough to have our seaside and country scenery disfigured by advertisements; we can surely afford to leave our sacred edifices free from such torments. But what a capital place a church would be for advertising in, if it were permissible, particularly when the sermon was dry and uninteresting! The weary listener would not go to church in vain, for he would have something engraven upon his memory, and that, the name of the electric light contractor.

"Science Siftings."—Our esteemed contemporary of this name, in its laudable desire to enlighten its readers upon the subject of Medical Electricity, and to suppress quackery, has hardly shown sufficient care in its selection, or rather admission, of an expert to deal with the subject. The first of a series of papers which has just commenced, and written by "Heretic," M.D., certainly does not promise well for the future. The writer may possibly know what he is writing about, but he certainly does not indicate that he has grasped the early principles involved in Ohm's law. Thus we are told, "Two cells, an inch square, will give nearly twice the current that one cell of any size larger will, because the potential is doubled." We would recommend the writer to try the experiment on the, so-called, "quantity" coil of a galvanometer, and see whether the current is doubled, or, indeed, perceptibly increased, when the number of cells is increased from one to two. Does not "Heretic" understand that although the electromotive force is doubled so is the internal resistance, thus the current remains the same. Again, we are informed that the Daniel (*sic*) cell is "the international unit of electromotive force." The human skin is stated to oppose a resistance of between 1,500 to 2,000 ohms, a statement as definite as the weight of a lump of chalk of the rustic mind. The following is, however, a clincher:—

> Place these elements in a belt, and allowing that the slightly moist skin has an acid of one-hundredth the efficacy of that of the sulphuric acid and water, the current from the belt in the external circuit (which does not circulate in the body) will be reduced to one-hundredth, and then add the resistance of the internal circuit, the piece of skin included between the elements, in this case a large tract, equal to at least 2,000 ohms resistance, *and the current comes down to nought*, so far as any provable action is concerned, for we had already got down to the $\frac{1}{20000}$th part of an ampère, and this skin resistance brings our available current down to the *vanished point, since a single ohm would extinguish an infinitely stronger current*; and this imaginary current does not flow through the body, but through the connecting wires, and on the surface of the skin. The currents evoked by the winking of an eyelid would possibly be as easily measured as would the current in the external circuit of an electric belt, which is tied round the waist (and costs £5 5s.); tied round your bedpost, it would be as useful. *It should be noted that the little bits of metal are polarised in one minute, the current then at once ceasing until the metals are polished clean again.*

(The italics are our own.) It would appear as if the science sieve is badly in want of repair. There appear to be a few large holes in the bottom which let through matter which was intended to be thrown on the waste heap.

Fire.—We regret to learn that a fire broke out last Saturday on the premises of the Hope-Jones Electric Organ Company, Limited, Argyle Street, Birkenhead. Damage to the extent of £1,000 was done, but this is covered by insurance.

Grange and Electric Lighting.—The Chairman of the Local Board intended moving that they obtain a provisional order, but when he found the cost of such order would be about £250, he would not make any proposition other than that he hoped the electric lighting question would not be lost sight of.

Fatal Accident.—Mr. Tom Duckworth, engineer, a well-known citizen of Carlisle, died, last Saturday night, in Cumberland Infirmary, from the effects of a very sad accident. His arm was caught in the electric lighting machinery at the public library, and the flesh stripped from the bone, while he also received a fearful blow on the head.

Sheffield Electric Lighting.—The new electric lighting station in Sheaf Street, belonging to the Sheffield Electric Light and Power Company, Limited, is now so near completion that the chairman and directors have issued invitations to the opening ceremony on Saturday next. At five o'clock the Mayor will switch on the current.

Stirling Electric Lighting.—Stirling Town Council have been overruled by the Board of Trade. They refused last year to consent to a company obtaining a provisional order. Advice upon electric lighting was sought at the hands of Mr. Arnot. The Board of Trade next interfered, and insisted upon the Council either applying for a provisional order, or consenting to the application of the electric light company. By a majority of two members, the Council have now decided to let the electric lighting powers slip from their fingers, and the company's application for an order will doubtless be granted by the Board of Trade.

Lectures.—At the monthly meeting of the Leeds Association of Engineers, a paper was read by Mr. Chas. J. Hall, on "The Generation and Distribution of Electricity."

On Wednesday, 7th inst., a lecture on "Electricity" was delivered by Mr. W. Perren Maycock at the Whitgift Grammar School, Croydon. At the conclusion of the lecture there was an electrical *conversazione* and exhibition of apparatus.

On Sunday last, at St. George's Hall, Langham Place, Mr. Henry Somerville, B.Sc., delivered a lecture on "The Birth and History of the Dynamo."

Inductor and Induced Part.—A discussion has lately arisen in England and America as to which parts of revolving field motors should be designated, respectively, by the names of "field" and "armature." With a continuous current motor there is no difficulty. The inductor is the part which produces the field, and it is traversed by a current *always of the same nature;* the armature is the part in which each wire, taken individually, is traversed by a current *varying in its nature.* With revolving field motors the current changes its nature in both parts at once, hence the difficulty. Prof. Ayrton is of opinion that that part in which the current varies with the least frequency should be called the "field," and that in which the variations are more frequent, the "armature." According to this definition, the field of a polyphased current motor would be the circuit closed upon itself, and the armature the part in which the alternating current circulates; Mr. Snell, however, gives opposite names to these parts. By adopting the French terms, "inductor" and "induced part" (*inducteur* and *induit*) in the place of the terms, "field" and "armature," all confusion might be avoided. In all cases the "inductor" is the part which produces the inductive field, whether constant or not; the "induced part" the part subjected to induction. These terms might be employed without any possibility of confusion, whether we are dealing with continuous, alternating or polyphased currents. We may also mention, says a French contemporary, two other terms which are beginning to be employed in English writings for distinguishing kinematically the two parts of a revolving electrical apparatus. The "stator" is the fixed part, and the "rotor" the movable one.

Lowestoft and Electric Lighting.—Enquiries are being made by the authorities regarding the cost of gas and electricity in other towns.

Derby Electric Lighting.—A Local Government Board enquiry was held on Tuesday regarding the borrowing of £5,000 for electric lighting purposes. This is required for new machinery and further mains. £3,000 is the cost of a dynamo alone.

Newport Tenders.—The cost of the Electric Lighting Sub-Committee's journey to Messrs. Crompton's works at Chelmsford amounted to £47 15s. They would not consent to Messrs. Crompton paying this sum, although several councillors would have been delighted to see the firm pay.

The Harness Prosecution.—One of the results of this prosecution is that Mr. Burbage, one of the prosecutors, has been served with writs for malicious prosecution. As Mr. Burbage took action in this matter solely in the interests of the public, and his costs have been already heavy, we are glad to see that our contemporary, *Science Siftings*, has opened a defence fund. Some subscriptions have been already received, and if our readers are inclined to help in this matter, the Editor of *Science Siftings* will be glad to receive donations.

New Use for the Phonograph.—In the vibration case of Wise *v.* the Metropolitan Electric Supply Company, to which we refer in our "Legal" columns, Prof. Silvanus P. Thompson, one of the witnesses for the plaintiffs, produced a very novel sub-witness, which had not to engage in any fencing with barristers, or tedious cross-examination, as it gave unmistakable evidence as to whether or no the noise from the Metropolitan Company's machinery was very objectionable, and no legal point could confuse or silence it. This novel witness was a phonograph, and its latest application may become a most useful one.

To our Readers.—We shall be glad if our correspondents will bear in mind that we go to press a day earlier next week, consequent on Good Friday. To ensure insertion, articles and correspondence must reach us not later than midday on Tuesday, and advertisements one day earlier than usual.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

British Electric Installation Contractors, Limited.—This company has been wound up voluntarily.

Electrical Engineering Company, Limited.—This company, states a document, has been wound up.

Dublin Electric Light Company, Limited.—The last return of this company was filed on January 18th, 1892, but since that date the concern has been wound up.

Faure Electrical Accumulator Company of Ireland, Limited.—According to an official document, this undertaking has been dissolved.

CITY NOTES.

Henley's Telegraph Works Company.

We are sorry to see that Henley's report for 1893 shows a considerable falling off in profits. There is a difference of nearly £5,000 between the profits of 1892 and 1893, the respective amounts for the two years being £15,456 and £10,777. The dividend of 5 per cent. on the ordinary and 7 per cent. on the preference is maintained, the reduced profits being shown in the lesser amount put to the reserve fund. It is manifestly difficult to say how much of this decrease is due to the cutting down of prices which was initiated during last year, and how much to the depression of trade which was experienced. We can say, of our own knowledge, that the company has been distinctly unfortunate in one or two contracts, which, under ordinary circumstances, they would have secured. With the £10,000 which it is proposed to add, the reserve account now stands at £46,019. The following comparative table does not show the 1893 accounts to be over satisfactory:—

	Net profit.	Amount carried to following year's account.
1891	£21,988	£11,731
1892	15,456	13,339
1893	10,777	5,137

but it must be pointed out that the year 1891 was an exceptionally good one for cable manufacturers.

Birmingham Electric Supply Company.

We shall not be able to deal with these accounts very fully until we have seen the Board of Trade returns. Judging from the directors' report, however, the company appears to have had a fairly good year. The net profit amounts to £5,247, out of which a dividend of 4 per cent. has been paid, £1,872 placed to depreciation reserve fund, and £250 to the general reserve fund. There is a satisfactory increase in the number of lamps connected, the number reaching, at the end of 1893, 10,223 against 8,329 at the end of 1892; there has been a still further increase, and at the present time over 11,000 lamps are connected. The company is about to extend its operations to Edgbaston and the Jewellers' Quarter, and a draft provisional order is now under discussion with the Corporation.

Hove Electric Lighting Company.

The company has issued the account and balance-sheet which cover the whole period since the formation of the company in August, 1892. The report is so satisfactory that we regret we cannot say anything this week about the cost of generation. So successful have been the operations of the company that a small profit had been earned at the end of 1893. With the probable termination of the Brighton and Hove Company's operations in Hove, an accession of customers is expected. The number of lamps now attached to the company's mains number 6,915, the number of houses supplied being 105.

As the capital expenditure exceeds by £9,000 the sum subscribed, the directors in their report urged the shareholders to subscribe for the balance of the company's shares.

The Oxford Electric Company, Limited.

The most satisfactory feature about the company's accounts is the remarkable economy effected in the cost of working. We do not propose this week to set out the cost of generation, but we would refer our readers to the report of the meeting of the company, which appears below.

The revenue account shows a gross profit of £1,105. After paying interest on debentures, the remaining balance of £68 is carried forward to next year's accounts. About 3,000 8-C.P. lamps have been added to the system. Ten colleges are now connected to the system, and others are expected to instal the light during the present year.

103,895 Board of Trade units were delivered to customers during 1893, and according to the directors' report, the cost of coal per unit does not exceed ·718d.

Newcastle-upon-Tyne Electric Supply Company.

In our analysis of this company's accounts, an error crept into the cost of repairs, which should have been ·45d. instead of ·79d. This reduces the total cost per unit to 2·78d. instead of 3·1d.

Cambridge Electric Supply.

As these accounts are not quite in accordance with the method prescribed by the Board of Trade, we cannot at present give a detailed cost of working, but we find that the total working cost comes to 5·86d., the average price obtained per unit amounting to a little over 6·9d.

The Oxford Electric Company, Limited.

The third ordinary general meeting of the shareholders of this company was held at the offices, 45, Broad Street, Oxford, on Saturday, March 10th.

The Chairman (Sir Henry Mance, C.I.E.), in presenting the report and accounts for 1893, said it had been extremely satisfactory to the directors that in consequence of a general settlement with the contractors they have been able to open the accounts of 1893 without bringing forward the adverse balance which appeared in the balance-sheet for the preceding year. There were several little differences to be adjusted between the two companies, but all their little differences with the contractors had now been adjusted, and he took the opportunity of expressing on behalf of himself and colleagues their entire satisfaction with the manner in which they had carried out the work and fulfilled their obligations. Turning to the accounts, he said that in the capital account there was an item of £273 expended for buildings. This was in payment for the transformer house at St. John's College, for another small sub-station in Holywell Street, and for a third in Magdalen College. During the coal strike it was considered necessary that a larger stock of coal should be kept in hand, and to properly protect this a shed has been erected at the works,

which was found to be a great convenience. The expenditure on account of mains, £1,293, had been rendered necessary by extensions in the direction of Holywell Street, Magdalen College, St. Giles's, King Edward Street, and St. Aldate's, the greater portion having been expended on the extension in Holywell Street and St. Giles's. He had some doubt whether the expenditure on college installations should properly be included in the capital account. However, that sum had been expended in fitting up certain colleges with the necessary installation in order to enable them to supply the light, all expenditure of this kind being guaranteed by the college authorities. If necessary, they were able to borrow what money was required for that purpose, and they received interest from the colleges sufficient to pay the interest on the loans. The colleges have the option of purchasing the installations at any time they pleased, and were bound to purchase eventually at the original price. Since January 1st about £800 of this sum had been paid off. They had still a small amount of debenture capital unissued, but this would be required probably for various extensions during the year, and they would easily be able to issue the debentures at par. Considering the short time the company had been in operation, he thought the revenue account was extremely satisfactory. They had written off nothing for depreciation, but, on the other hand, there was an item of £396 for the maintenance of machinery and plant. With the exception of the batteries, which, of course, could not be expected to last for ever, the plant was in better order now than when it was first laid down. The management expenses were extremely moderate. With regard to the item of £346 profit on installations and other work, the company had carried out some important installations during the year, and also derived a reasonable profit on the sale of lamps and other articles. They did not, however, desire to undertake work of this kind, unless at the particular wish of the consumer, preferring to leave these installations and contracts to those who make it their sole business. Passing on to the balance-sheet, he said that the £1,155 due to sundry creditors had been considerably reduced since the commencement of the year; nearly £800 of this sum was due to expenditure on capital account for mains, arc lamps, meters, and buildings. After providing for debenture interest, there remained a balance to the credit of the net revenue account of £68 8s. 5d., which had been carried forward to the present year. Their relations with the authorities continued of an entirely satisfactory character. The number of 8-candle-power lamps connected to the system had increased from 4,040 to 7,012 on December 31st, 1893. The number of consumers had increased from 65 to 100, colleges being counted as one only, unless there are separate installations within the same college. Amongst their customers they had 10 colleges, 51 shops, 5 hotels, 6 clubs, and 15 private houses, the remainder consisting of the theatre, one church, and various offices. They were steadily adding to the number of customers, and the following university buildings are now considering the advisability of installing the light:—Magdalen Schools, Wadham, Exeter College, and the University Galleries. Trinity College is expected to make a large extension of their light almost immediately. Should all these be connected to the system, it would probably mean the equivalent of an additional 1,500 8-candle-power lamps. They thought they saw their way to another 1,500 in other quarters, and as they had at the present moment about 7,500, they might reasonably hope to see at least 10,000 lamps installed before the end of 1894. Their length of trenching had increased from 6,500 to 7,490 yards, and their low tension supply mains from 12,000 to 13,980 yards. They had extended their high tension mains to Holywell Street, and Magdalen and St. John's Colleges; 1,025 yards of iron piping had been put down, and the lengths of high tension mains increased from 10,500 to 12,700 yards. Two new sub-stations had been established, namely, those in St. John's College and Holywell Street, and one had been transferred at a trifling expenditure from King Street to Magdalen College. 103,000 Board of Trade units were supplied to customers during the year, the best week's revenue being £144, as compared with £86 during 1892. Eighteen per cent. of the current sent out to customers had been supplied from the batteries while the machinery has been at rest. The use of a small bank of storage cells had enabled them to dispense with one shift of men, and rendered it unnecessary to move the machinery before the hour when a remunerative load might be expected. They proposed extending their mains almost immediately to Beaumont Street, Pembroke College, across Magdalen Bridge to the new Magdalen Schools, and the square on the other side of the bridge. The question of extending the mains so as to embrace the residential district in the north of Oxford was receiving serious consideration. Throughout the year there had been a complete absence of any accident. The cost of the production of the current at the works came out rather less than 4d. The efficiency of the system worked out at about 62 per cent. Notwithstanding the coal strike and the increased price of coals, the amount of coal expended per Board of Trade unit delivered to the customers had only cost $\frac{7}{10}$ths of a penny. They had 7,500 lights connected with the mains, whereas their present capacity was at least 15,000, and it was a very hopeful feature for the future that the station could be, at a comparatively small expenditure, so expanded and altered as to bring the capacity up to 30,000 or 35,000 lamps if necessary.

Mr. L. A. Selby Bigge seconded the motion, which was carried, as were also resolutions re-electing directors and auditors.

Hove Electric Lighting Company.

The second annual general meeting of the Hove Electric Lighting Company, Limited, was held on Wednesday afternoon at the Town Hall, Hove, Colonel H. Woods, C.B., presiding. He said he had the pleasure of congratulating the shareholders on the continued satisfactory progress of the company, the number of lights connected continued to increase, and it was expected that before the end of the current year the number of lights would be more than double the number on December 31st last, and that they would then have 14,000 or 15,000 connected up. The exact number now was 12,600. When it was considered that the actual expenditure of the company would probably at that time not exceed £35,000 or £40,000, it must, he thought, be admitted that, compared with what was done by many other companies, this was extremely satisfactory. To take, for instance, one of the large London companies, which had a capital expenditure of £77,000, or nearly double what would probably be their expenditure as shown in the next balance-sheet, the number of the lamps connected was 12,153, against the 14,000 or 15,000 which the directors of this company would have connected at the end of the year. That surely must be considered a satisfactory result to be obtained by a new company in such a short time. In addition to the private lights, it was hoped that before the end of the year the Hove Commissioners would put up some public lamps along the Front if not in some of the streets, and this would add materially to the business of the company, and be an advantage to the public in Hove. To ensure the continued success of the company, and to enable them to meet the calls upon them by intending consumers, further capital was required. Hitherto their contractors, Messrs. Crompton & Co., had promptly executed all orders, and had met the directors in every way, but extension was necessary on such a scale, that it would not be prudent for the directors to enter into any fresh contracts unless further capital was subscribed. There was another matter upon which the directors were able to congratulate the shareholders—the retirement of the opposition company from the field, thus giving this company the monopoly. The competition between the two companies had been both fair and straightforward, and now that the other company were retiring from the field, they were advising their customers to come over to the underground system. Though they sympathised with the shareholders in the other company, they anticipated that the result of its withdrawal from the field would be that the Hove Electric Lighting Company would do more business. Dealing with the present condition of affairs, he said the directors proposed to offer the balance of the shares to the public, and at the same time issue a debenture prospectus. The shareholders would be asked to empower the directors to issue more debentures than by the articles of association they had now the power to do; but it was intended to make a higher issue than £12,500 for the present, though it was proposed that this sum should form part of a total of £25,000 when the magnitude of the works justified the directors in making such an issue. He concluded by proposing the adoption of the report.

This was seconded by Mr. C. F. Tufnell.

Mr. J. Cash observed that the accounts did not show the number of units which had been sold. He had written to the secretary respecting that point, but had not yet received the information. It was impossible, without such a statement, to make any comparison between the working of this company and of other companies as to the cost of production.

The Secretary said he was sorry Mr. Cash had not received the information which he had asked for; but he had been away from his office through illness for a month. He, however, had figures before him, and would send them on to Mr. Cash in due course.

The motion was then agreed to.

The Chairman then proposed: That the directors be and they are hereby empowered to borrow or raise any sum or sums of money on such security and upon such terms as to interest or otherwise as they may deem fit, and for the purposes of securing the same and interest or for any other purposes may create, issue, make, and give respectively perpetual or redeemable debentures or debenture stock, or any mortgage or charge upon the undertaking or the whole or any part of the property, present or future, or uncalled capital of the company, provided that they shall not, without the further sanction of a general meeting of the company, borrow or raise any sum of money exceeding, in the whole, £25,000.

Mr. Tufnell seconded, and the Secretary, in reply to Mr. Woodruff and Mr. Cash, having explained that it was necessary for the shareholders to agree to this resolution before the directors could raise more than £10,000 by debentures, and that this total sum of £25,000 would include this £10,000, the motion was agreed to.

Direct Spanish Telegraph Company, Limited.

The report of the directors for the half-year ended December 31st, 1893, to be presented at the general meeting of shareholders to be held on Tuesday, 20th inst., states that the accounts for the half-year ended December 31st, 1893, show, after providing for debenture interest, a balance to the credit of profit and loss of £4,996 7s. 1d. The traffic receipts show a decrease of £509 15s. 4d. as compared with the corresponding period of 1892. This falling off in the receipts is entirely owing to the general depression of trade during the half-year. The working expenses are £35 18s. 6d. less than those for the corresponding period of last year. The company's cables, and the land-lines in connection with them, have with one exception continued in good working order throughout the half-year. The Falmouth-Bilbao Cable became interrupted on August 16th, 1893; it was, however, promptly and effectually repaired on August 24th by the Eastern Telegraph Company's cable ship *Electra*. The cost of these repairs, amounting to £1,453 18s. 9d., has been taken from the reserve fund, and it is intended to repay this amount to that fund out of future profits. A branch telegraph office of the company was opened on November 6th, 1893, in the Foreign Auction Hall, Covent Garden Market, where a great portion of the fruit trade with Spain is carried on. The results are satisfactory. After adding the usual sum of £2,500 to the reserve fund, the balance of profit and loss amounts to £2,496 7s. 1d. Out of this amount the directors recommend the payment of the dividend at the rate of 10 per cent. per

annum on the preference shares, and a dividend at the rate 4 per cent. per annum (free of income tax) on the ordinary shares, and to carry forward the balance. The reserve fund will then amount to £37,551 11s. 10d. Sir John Pender, G.C.M.G., M.P., and Mr. E. Etlinger are the directors retiring by rotation, and offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., retire, and offer themselves for re-election.

Elmore's German and Austro-Hungarian Metal Company.

An extraordinary general meeting of this company was held on Monday, at Winchester House, for the purpose of passing resolutions to the effect that the second special resolution passed in June, 1892, be rescinded, and that the new shares authorised to be created by the first special resolution passed at that time, and the 25,000 shares now unissued of the original capital of the company, should be called preference shares.

Mr. J. MacFarlan, who presided, said the directors were able to report a far better state of things than had previously existed, and that the company was now unquestionably a success. The company had been passing through a most trying time owing to the want of the necessary capital, and it had only been by the directors personally assisting the company to a considerable amount that they had been able to prevent it going into liquidation. Now, however, they were in the satisfactory position of having received a Government contract for the supply of all copper tubes between 7 inches and 12 inches in diameter that would be required by the docks at Kiel, Wilhelmshaven, and Dantzig for the next three years. The Chairman referred to the continual struggle for existence which the company had had, and stated that the directors had used every endeavour to raise the necessary capital. The board, he continued, were fully aware that the proposed issue of preference shares was a very stringent measure to adopt, but they believed it to be the only feasible method of saving the company and of averting heavy loss to the shareholders. It was proposed that only 15,000 of the shares should be allotted, and this should give them £30,000. When once the issue was made they could immediately put down additional plant, purchase copper, and, so soon as erected, they could accept the contracts offered to the company, and it would then be only a question of weeks defore they were able to earn sufficient money to set aside an amount for dividends.

After some discussion the resolutions were passed conditionally, the directors agreeing not to carry them into effect if an alternative scheme which was presented (having been prepared by Mr. Elmore) could possibly be carried out.

Oriental Telephone and Electric Company, Limited.

An extraordinary general meeting of this company was held last Monday at the Cannon Street Hotel, Mr. William Addison presiding, for considering the confirmation of the resolution passed at the meeting on the 21st ult. for winding up the company voluntarily with a view to its reconstruction and incorporating a new company of the same name, and with a nominal capital of £200,000, in shares of £1, to take over the assets of the present company.

The Chairman stated that they had been advised by the auditors that the new company could only earn a dividend as from the period of its registration, and, consequently, the dividend the shareholders would receive next year would only be from the profits of the company for about 9½ months. They therefore proposed that the distribution, which the liquidators would make as soon as they possibly could, should be for the 14½ months up to that day from January 1st, 1893. The distribution would be made on the whole of the paid-up capital of the company, this being a part of the agreement of the scheme they were now carrying out. It would be equal, as nearly as possible, to 4½ per cent. per annum for the period mentioned on the amount of the reduced capital and be free of income tax. Notwithstanding that the vendor shares participated in this dividend, the holders of ordinary shares of 11s. would receive a slightly improved dividend on that paid last year.

The Solicitor (Mr. Joseph Addison), in answer to Mr. Norris, said that under the scheme the ordinary shareholders and the vendor shareholders would participate in a certain way as from December 31st, 1892.

Mr. Norris said that he had distinctly understood from what was said at the last meeting, and from the report, that there was no intention of distributing any dividend for the year 1893 to the holders of the vendor shares.

The Chairman replied that it was never the idea of the directors in the arrangement come to with the vendors.

The resolutions were then confirmed.

Bath Electric Light Company, Limited.

The annual meeting of the shareholders was held on Wednesday last week, Mr. Callender presided.

In moving the adoption of the report, the Chairman said they found the mode of supplying the light under contract was not so satisfactory as it should be. People burnt much more light than was expected, or was necessary. They had therefore adopted the system of payment by meter, which was the fairest and best. By a little care in the use of the light, the consumer found there was no extra charge, and looking through the accounts for the past six months, they found they were about the same as the contract amounts. They could supply many more lights without adding to their expenditure, and he asked the shareholders to do all they could to obtain extensions. Mr. Metzger had been appointed manager, and the machinery and plant had been thoroughly improved; they thanked Mr. Metzger and the staff for the way in which the economies had been carried out. The station looked very well indeed. Expensive alterations and repairs had been charged to revenue; they had not followed the example of many companies and charged everything to capital account. Had they done that they would have shown a profit instead of a small loss.

Answering Mr. Titley, Mr. Pitman, a director, said the receipts in 1890 were £1,100 less than in 1892, and the expenses were £1,700 less. That was due to the fact that they had been improving the works rather than seeking new installations.

Willans & Robinson, Limited.—This company has been formed with a capital of £300,000, to take over and extend the business of Willans & Robinson, Limited, which has been carried on with increasing success during the past 13 years. Owing to the great increase in the demand for the company's engines, it has been found necessary to largely extend the works and plant. The company has accordingly been reconstituted upon a wider basis. The capital is divided into 30,000 6 per cent. cumulative preference shares of £5 each, and 30,000 ordinary shares of £5 each. The issue for which applications are invited will consist of 8,037 preference and 8,038 ordinary shares. 14,463 preference and 14,462 ordinary shares will be allotted in part payment of purchase money, and 7,500 shares of each class are reserved for future issue. The preference shares will rank in priority to the ordinary shares both as to capital and dividend. The directors of the company are to be Mr. M. Robinson, chairman, Sir Gilbert A. Clayton-East, and Capt. Sankey, R.E. We refer our readers to page 3 of the supplement for further details.

The Edison and Swan United Electric Light Company, Limited.—The directors have resolved that a payment on account of the dividend of the current year be made at the rate of 5 per cent. per annum, less income tax, on the "A" shares of the company, for the half-year ended December 31st, 1893. This will work out as follows:—On the 89,261 ordinary shares, £3 paid, 1s. 6d. per share; on the 5,000 shares, £5 paid, allotted to the Edison Electric Light Company, Limited, 2s. 6d. per share; on the 12,139 shares, £5 paid, allotted to the Swan United Electric Light Company, Limited, 2s. 6d. per share, less income tax. The payment will be made upon the register as it stands this day, and the dividend warrants will be issued on the 20th inst.

Hastings Electric Light Company.—In their report for the year ended December 31st last, just issued, the directors of the Hastings Electric Light Company state that a considerable sum has been spent on new plant and extensions to meet the large increased demand for electric lighting, and although the receipts are much in excess of the previous year, the full advantage of the outlay will be derived in the future. The sum of £964 15s. 7d. remains for dividend. Out of this the directors recommend the payment of 5 per cent., and the carrying forward of the balance of £75 11s. 10d. The retiring directors are Messrs. F. A. Langham, J. Reeves, and J. Woodhams, who offer themselves for re-election.

Commercial Cable Company.—The report for 1893 shows that the gross receipts were $1,842,346, the working expenses $784,600, and the net income $1,057,746. As compared with 1892, these figures exhibit decreases of $48,030, $6,189, and $41,841, respectively. Dividends were paid at the rate of 7 per cent. per annum, absorbing $613,376, and of the remaining $444,370 the sum of $389,600 was applied in January last to the repayment of the remainder of the debenture bonds. The new cable is to be completed by July 15th. Its guaranteed working speed is to be a third greater than that of the company's present main Atlantic cables.

Eastern Telegraph Company—The directors announce the payment on April 13th next of interest of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum on the preference shares for the quarter ending March 31st, and the usual interim dividend of 2s. 6d. per share on the ordinary shares, free of income tax, in respect of profits for the quarter ended December 31st. The register of transfers will be closed from April 6th to 13th, both days inclusive.

Stock Exchange Notices.—The Stock Exchange Committee have appointed March 16th as a settling day for the following, and have also ordered that the securities be quoted in the Official List:—City of London Electric Lighting Company, Limited—Further issue of 20,000 6 per cent. cumulative preference shares, Nos. 20,001 to 40,000.

Pontypool Electric Light and Power Company, Limited.—The second annual meeting of shareholders was held last Friday, a dividend of 2½ per cent. being declared.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending March 11th, 1894, amounted to £980; week ending March 12th, 1893, £859; increase £71; total receipts for half-year, 1894, £9,474; corresponding period, 1893, £9,532; decrease, £58.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 9th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,252.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, March 7th.	Closing Quotation, March 14th.	Business done during week ended March 14th, 1894. Highest.	Lowest.
184,500£	African Direct Teleg., Ltd., 4 % Deb.	100	...	...	...	100 —103	100 —103	...	...
1,134,640£	Anglo-American Teleg., Ltd.	Stock	£2 12s.	£2 15s.	£2 11s.	42 — 44	42 — 44	42¼	42
2,932,680£	Do. do. 6 % Pref.	Stock	£5 5s	£5 10s.	£5 2s.	79 — 80	78½— 79½	80	78⅜
2,932,680£	Do. do. Defd.	Stock	...	...	...	7 — 7½	6⅞— 7⅛	7⅛	7
130,000	Brazilian Submarine Teleg., Ltd.	10	8 % §	6¼% §	6¼% §	11⅜— 12¼	11¼— 12¼	12⅛	11⅝
18,700£	Do. do. 5 % Bonds	100	...	...	...	99 —102	99 —102	...	...
75,000£	Do. do. 5 %, repayable June 1906	100	...	...	...	107 —111	107 —111	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	... §	10%‖ §	... §	2 — 3	1½— 2½	1 9/16	1½
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	...	135 —145	145 —150	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	3½% §	2 % §	... §	1/16 — 3/16	1/16 — 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12 — 13xd	12 — 13	12⅛	12⅜
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	18 — 19 xd	18 — 19	...	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4½%	4 %	...	2 — 3	2 — 3	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	...	8 — 9	8 — 9	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	3½% §	...	10⅜— 11	10⅜— 11	11	10⅞
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	15 — 15½	14⅞— 15	15 3/16	14⅝
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	15⅜— 16½	15⅞— 16⅛	16⅛	16 1/16
105,900£	Do. 5 % Debs., repay. August, 1899	100	...	...	...	106 —109	106 —109	...	...
1,294,100£	Do. 4 % Mort. Deb.	Stock	...	...	...	114 —117	114 —117	115½	114
250,000	Eastern Extension, Australasia and China Teleg., Ltd.	10	7 %	7 %	...	15½—15¾	15¼— 15½	15⅝	15¼
62,700£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	...	...	...	103 —106	103 —106	...	...
222,800£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	...	...	...	103 —106	103 —106	...	...
320,000£	Do. 4 % Deb. Stock	Stock	...	...	...	114 —117	113 —116	113¼	113
95,100£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	...	...	...	103 —106	103 —106	103½	...
129,100£	Do. do. do. to bearer, 2,344 to 5,500	...	...	...	...	103 —106	103 —106	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	...	...	...	103 —106	103 —106	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	...	...	...	107 —110%	107 —110%	108	...
180,227	Globe Telegraph and Trust, Ltd.	10	5¼% §	4⅓% §	4⅝% §	8⅜— 9	8⅝— 8⅞	9	8⅝
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	6 % §	15¼— 15½	15¼— 15½	15¼	...
150,000	Great Northern Teleg. Company of Copenhagen	10	8¾% §	8¾% §	...	21 — 22	21 — 22	...	...
200,000£	Do. do. do. 5 % Debs.	100	...	...	...	104 —107 xd	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	42 — 45	43 — 45	44	...
37,548	London Platino-Brazilian Teleg., Ltd.	10	...	...	...	4 — 6	4 — 6	...	...
100,000£	Do. do. 6 % Debs.	100	...	...	...	104 —107 xd	104 —107	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	½— 1½	½— 1½	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	...	...	...	2 — 3	1 — 2	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	6 % §	5 % §	...	4½— 4⅝	4½— 4⅝	4⅝	4 9/16
15,000	Do. 6 % Cum. 1st Pref.	10	...	...	...	14½— 15½	14½— 15½	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	...	...	...	14 — 15	14 — 15	14⅝	14 9/16
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	...	...	...	5½— 5⅝	5½— 5½	5 7/16	...
925,017£	Do. 4½ % Deb. Stock Prov. Certs.	...	...	...	...	113 —115	113 —115	115	114¼
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
220,000	Oriental Teleph., Ltd., 80,001 to 300,000; 11s. paid	1	2¼%	3⅝%	...	¼— ⅜	¼— ⅜	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	...	...	...	102 —105	102 —105	...	...
11,839	Reuter's Ltd.	8	5 %	5 %	...	5½— 6½	5½— 6½	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	113 —118	113 —118	...	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1½— 2	1½— 2	1⅝	...
146,370£	Do. do. 5 % Debs.	Stock	...	...	...	90 —100	90 —100	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	4 %	..	...	3 — 5	3 — 5	...	...
249,900£	Do. do. do. 5 % Debs.	100	...	...	...	98 —101 xd	98 —101	99	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	2 — 2½	2 — 2½	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	...	...	...	97 —101	97 —101	99	...
64,242	Western and Brazilian Teleg., Ltd.	15	4 %	2½%	...	7½— 7⅝	7½— 8	...	...
33,129	Do. do. do. 5 % Cum. Pref.	7½	...	...	...	5½— 6	5⅝— 6¼	6	...
33,129	Do. do. do. 5 % Def.	7½	3 %	...	...	1⅞— 2¼	1⅞— 2¼	...	...
178,200£	Do. do. do. 6 % Debs. "A," 1910	100	...	...	...	104 —107	104 —107	...	...
222,700£	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	...	...	...	104 —107	104 —107	...	...
88,321	West India and Panama Teleg., Ltd.	10	¼%	¼%	...	1⅛— 1⅜	1⅛— 1⅜	...	...
34,563	Do. do. do. 6 % 1st Pref.	10	...	...	...	10 — 10½	10 — 10½	10¼	...
4,669	Do. do. do. 6 % 2nd Pref.	10	...	...	..	8¼— 9½	8¼— 9½	9 1/16	8⅞
80,000£	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	...	...	...	106 —109	106 —109	...	...
$1,214,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds	$1000	...	...	...	113 —118	113 —118	115	...
169,000£	Do. do. 6 % Ster. Bonds.	100	...	...	...	100 —104 xd	100 —104	103¾	...

ELECTRICITY SUPPLY COMPANIES.

20,510	Charing Cross and Strand Electy. Supply, 1 to 6, 215 to 718, and 10,001 to 30,000	5	...	5 %	4½%	4 — 5 xd	4 — 5	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,000—180,000	10	...	...	...	11 — 12	11 — 12	11⅜	11½
20,000	Do. do. 6 % Cum. Pref., 1 to 20,000	10	...	6 %	6 %	13 — 13½xd	13 — 13½	13 7/16	13
19,900	*Electy. Supply Co. of Spain, 101 to 20,000	5	...	...	...	... ...	... ...	...	...
30,000	†Liverpool Electric Supply, £4 10s. paid	5	...	...	...	5½— 5⅝	6 7/16— 6½	5⅝	5⅝
15,000	Do. do.	5	4½%	5 %	...	6½— 6⅝	6⅝— 6¾	6⅞	6¼
49,900	*Metropolitan Electric Supply, Ltd., 6,101 to 50,000	10	1 %	2 %	...	8¼— 8⅜	8¼— 8⅜	8⅜	...
100,000£	Do. 5% Deb., 1 to 10,000 in bonds of £10, £20, £40	...	...	...	...	106 — 109	106 —109	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	...	4½— 5½	4½— 5½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	8½%	7¼%	4½%	6 — 6½	6 — 6½	6¼	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8 — 8½	8 — 8½	...	...
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000	5	...	3¼%	4 %	5½— 6 xd	5⅝— 6¼	6⅛	5 11/16

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING AND INDUSTRIAL COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1891.	1892.	1893.	Closing Quotation, March 7th.	Closing Quotation, March 14th.	Business done during week ended March 14th, 1894. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000	3	...	6 % §	6 % §	2⅝ — 2⅞xd	2⅝ — 3	2 13/16	2⅞
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	...	6 % §	6 % §	2⅛ — 2⅜xd	2⅛ — 2⅜	2 5/16	2 3/16
125,000*l*	Do. do. 4½ % Deb.	Stock	...	...	...	106 —109 xd	107 —110	...	...
630,000*l*	City and South London Railway	Stock	...	⅝%	⅝%	27 — 32	27 — 32	...	...
20,000	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 20,000	5	7 % §	7 % §	7 % §	3½ — 4	3½ — 4	...	...
50,000*l*	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	...	...	...	97 —102	97 —102	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	...	...	...	¼ — ¾	¼ — ¾	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	...	...	...	1⅛ — 2	1⅛ — 2	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd, 1 to 66,750 ...	2	*nil*	*nil*	*nil*	⅛ — ⅜	⅛ — ⅜	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil* ¶	*nil*	*nil*	⅛ — ⅜	⅛ — ⅜	...	...
67,385	Elmore's Wire Mfg., Ltd., 1 to 67,385, issued at 1 pm. ...	2	*nil*	*nil*	*nil*	⅝ — ⅞	⅝ — ⅞	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	*nil* §	½ — 1⅛	½ — 1⅛	...	...
12,134*l*	Greenwood & Batley, Ltd., Ord., 4,667 to 16,800	10	...	...	...	4½ — 5½	4½ — 5½	...	...
9,600*l*	Do. do 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	...	...	6½ — 7½	6½ — 7½	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	12½%	23 — 24 xd	23 — 24	24	23⅝
200,000	Do. do. do. 4½ % Deb., 1896	100	...	...	...	103 —105	103 —105	...	...
11,334	International Okonite, Ltd., Ord , 22,667 to 34,000 ...	10	5 % §	...	...	1 — 2	1 — 2	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	...	1 %	5¼ — 5½xd	6¼ — 6½	6¼	5
6,295	† Do. do. Pref., £8 paid	10	...	...	...	9 — 9½xd	9½ — 9⅝	...	...
78,949	Swan United Electric Light, Ltd., £3½ paid	5	11 % §	10 % §	7½% §	2 — 2½	2 — 2½	...	...
37,250	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	20 %	39 — 41 xd	39 — 41	40	39½
150,000*l*	Do. do. do. 5 % Bonds, red. 1894	100	...	...	...	... ...	... ...	...	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%§; 1891—7%§; 1890—8%§.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5⅜—5¾.
Brush Company, 4½% Debenture Stock, issued at 1% premium, 106—108.
Electric Construction Corporation, 6 % Debentures, 87—92.
Electric and General Investment, shares of £5 (£1 paid), 1¾—2¼.
Electricity Supply Corporation, Ordinary of £5, 5—5½.
House-to-House Company (£5 paid), 1—1½.
Do. do. 7 % Preference, of £5, 5¼—5½.
Do. do. 6 % Debentures of £100, 101—103.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 4⅜—5¼; 1st Preference Cumulative 6 %, £5 (fully paid), 6⅛—6⅜.
Liverpool Electric Supply, £5 (fully paid), 6½—6¾.
Do. do. £3 10s. paid, 4½—4⅝.
London Electric Supply Corporation, £5 Ordinary, ⅞—1⅛.
Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 101—103.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares (£4 10s. paid), 4¼—4⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

On Parallel Working, with Special Reference to Long Lines, by W. M. Mordey, Member. Paper read Thursday, March 8th, 1894.

In his reply at the end of the discussion on his Niagara paper, Prof. Forbes alluded* to some experiments which he had witnessed, and which he considered showed that alternators of my design would not run properly in parallel. The passage is as follows: "At the time when I recommended the Mordey machine I said that, before deciding to adopt it, tests must be made with a resistance between the dynamos in parallel. Does Mr. Mordey forget that, when he kindly placed at my disposal the means of making this test, by putting 'Sunbeam' lamps in series—that is to say, between the two dynamos working in parallel—the lamps went up and down in brightness with the periodicity of a few seconds, and that the tendency was to rise to maximum brilliancy, showing that the dynamos were rather working in series than in parallel? From the moment of those experiments, I felt that that type of machine was not suited for our purposes, though I never mentioned that, until I was compelled to by Mr. Mordey's claims for his special mode of working." I heard his remarks with the utmost astonishment, as the experiments, rightly interpreted, appeared to afford the very strongest proof of the exceedingly powerful synchronising effort exerted by these machines, and because I then heard a contrary view expressed for the first time.

And in another passage Prof. Forbes stated that they must have alternators at Niagara that will run without any synchronising or waste current.

The matter is of some moment, and demands an explanation. With your permission, I will make this explanation the text and starting point of a paper on parallel working, and on the allied subject of the use of alternators as synchronous motors. The experiments were made in July, 1891, and were the subject of a leading article in the *Electrician* of July 16th, 1891, and were mentioned in the Electrical Review and elsewhere, in each case as having afforded an illustration of the thoroughly satisfactory parallel working of alternators when directly coupled to high-speed engines—a matter with regard to which there was at that time some uncertainty. It had been supposed that some flexible or yielding coupling was necessary between the engine and alternator. For my own part, I never had any doubt on the subject; but in order to place the matter beyond dispute some tests were carried out by the Brush Electrical Engineering Company and Messrs. Willans & Robinson. The former provided two of my alternators, the latter fitted them to two Willans engines. Amongst others, Prof. Forbes received an invitation to witness the trial, and was present.

When all the tests of ordinary parallel working had been satisfactorily carried out—including shutting the steam off the engine driving one of the alternators, and then applying a brake to its flywheel in a vain attempt to force it out of step—a further test was made (as an interesting experiment bearing on the subject of synchronous motors) to ascertain what would occur if the two alternators were coupled together with a resistance between them so great that the resistance alone would be sufficient to absorb the whole power of one machine, even if the machine at the other end were at rest; and the remarkable fact was established that even under these conditions (which would be absolutely absurd or impossible in practice) the two machines did not break out of step.

The resistance used consisted of "Sunbeam" lamps, which happened to be the only suitable resistance available. These lamps, being made for 80 volts and about 5 ampères, would have a resistance, hot, of about 20 ohms each, and a much higher resistance when cold—probably more than 30 ohms. Seven of these lamps were placed in series between the alternators. There was no other external circuit. It was then found that there was a current passing through them which rose and fell with a slow pulsation; the alternators, although not actually breaking out of step, evidently getting a good deal out of true co-phasal synchronism, and only being pulled in when this slowly pulsating current rose to a considerable amount. Synchronism being regained, the current decreased again. This current was not measured, but was probably about 7 ampères, as the lamps were a good deal over-incandesced. The experiment was then discontinued.

Properly interpreted, this test appeared to show that, even when a line of an enormously high resistance was interposed between two alternators arranged to run in parallel (or one as generator, the other as synchronous motor), and when no adjustments were made to help them to keep together, the tendency to get out of step was corrected with a surprising amount of success; the correction, instead of being instantaneous and powerful, as with machines connected through a small resistance only, being sluggish, and greatly weakened by the effect of the very high resistance of the line.

To show how utterly unfair and unjust Professor Forbes's interpretation is, and to reassure those who may desire to use synchronous motors, it is only necessary briefly to examine the conditions of the test.

* *Journal*, xxii., 607.

The two alternators used in the experiment were 37·5-kilowatt 2,000-volt machines. At full load each would therefore give nearly 20 ampères. Now, suppose it is desired to run one machine as a generator, driving the other as a synchronous motor (to take the illustration that may best suit the case of power transmission over a considerable distance), it will be seen that, if the line is to be designed to give such a percentage loss as is proposed for the Niagara-Buffalo transmission (that is, 3·5 per cent.),* the loss at full load should be 70 volts, and, the maximum current being, say, 20 ampères, *the line resistance should be* 3·5 *ohms*. In the actual experiment, the machines did not break out of step even when the line resistance was *more than* 100 *ohms*—that is, relatively more than 30 times greater than Professor Forbes proposes to use even for his long-distance transmission. This is the more striking as a proof of their powerful synchronising when it is considered that, even if it had been intended to expend the whole power of the generator in the line, that line should only have had a resistance of 100 ohms. That these machines did not act quite perfectly in parallel under these conditions, even with no load, is not to be wondered at. The only cause for surprise is that they exerted any sensible synchronising effort at all. It is exactly as if an attempt had been made to run two 1,200-kilowatt alternators in parallel through a line constructed to allow a reasonable loss for a couple of 40-kilowatt machines. Even unloaded, such a test would be unreasonable.

I now wish to refer to the "hunting" or regular pulsation of current, shown by the slow changing of the lamps from blackness to high incandescence, which is a matter of considerable interest. It may have been caused by self-induction, or, as, in this connection, it is sometimes termed, armature reaction—that is, the effect of the self-induced field produced by the armature in disturbing the impressed field of the field magnet. Although this effect may in some cases be considerable, I think we must look elsewhere for it in this case, because in the machines in question such reaction would have been inconsiderable, even if the phase relation had been most favourable to it. This I may illustrate by saying that if the armature current had been commuted, and passed round coils on the field poles having turns equal in number to the armature coils, the effect on the field would have been inconsiderable.

I think an explanation of the "hunting" will be found in the character of the resistance, and in the governors of the engines.

The change in the resistance of the lamps accounts largely for the pulsation. When black they would interpose a very high resistance—probably about 200 ohms—then as the machine got a little out of step, the synchronising current would heat them, reduce their resistance, allow a much readier transfer of power, and so bring about a restoration of true synchronism, and a reduction of current through the lamps. This series of effects, being constantly repeated, goes a good way towards explaining the pulsation. Probably without this lowering of the resistance by the incandescing of the lamps, synchronism would not have been maintained at all.

Then, again, the governors of the engines must be considered. If they pulsated with the same period, but opposite phase, the action is explained; they would, at any rate, accentuate the "hunting," if they did not start it. Messrs. Willans & Robinson have kindly sent me an indicator card, taken by Mr. Willans at the time, which supports this view, the steam being shown as having been widely varied during the taking of the card.

Fig. 1.

This must not in any way be taken as a reflection on the governors. The conditions were very trying for any governors, there being no load, and no opportunity occurred of specially adjusting them. If we had governed by hand at the stop valve, this "hunting" would not have occurred. Nor would it have occurred if we had adjusted the E.M.F. of one machine so as to allow it to run as a motor all the time. What happened appeared to be a repeated change in the functions of the two machines, from generator to motor—first one racing, and then the other, driving the second one as a motor.

The condition of entire absence of synchronising current or of correction can only be obtained by driving by engines that are very even in power always. I think this is more likely to be approached by turbines than by reciprocating engines. By "synchronising current" I do not mean necessarily an actual current passing from one alternator to the other—this only occurs when one of them is driven as a motor—I mean the variations of the current contributed by each machine to the circuit. But I would like to point out that the condition laid down by Prof. Forbes as an essential—namely, that they must have alternators at Niagara that will run without any synchronising or waste current—is an absolute impossibility.

Alternators will run without synchronising current only when there is no necessity for them to exert any synchronising effort. However, I am glad to find that Prof. Forbes has set himself to solve this problem of getting an alternator motor to run without any current (for that is what it amounts to), because I am sure that in solving it he will also have disposed for ever of that other interesting problem—making a motor that will run without any back electromotive force. This is a new and significant outcrop of the "perpetual motion" idea.

* *Journal*, xxii., 516.

I am sure that if Prof. Forbes had really considered or understood this matter he would not have expressed the opinion which I have quoted. At the same time I wish to say I am convinced that his criticism was not unfair by intention.

The necessity for correcting a false impression has forced me to take the first opportunity of bringing this matter before the Institution. I regret that Prof. Forbes is abroad, but he will, of course, have an opportunity of sending on for the *Journal* any observations he may wish to make.

It was not my intention to do more than make the above explanation, feeling sure that it would be sufficient to enable the Institution to form a correct judgment on the circumstances; but, as I am permitted to occupy more of your time than I expected, I wish to refer to some tests that I have been able to make.

It appeared desirable to give the results of actual trials, preferably working one machine as a synchronous motor, and not merely as one of a pair of parallel connected generators.

It will be granted that the action of synchronous motors and of parallel alternators is very similar. But with regard to the trials just referred to, it might fairly be argued that as each alternator had a steam engine behind it, on which it could fall back for assistance, something more is wanted to actually prove that the explanation is applicable to the case of a synchronous motor, relying entirely on its own motor properties.

I am therefore glad to be able to place before you the results of some tests made in the works of the Brush Company.

Some Tests of a 25-Kilowatt Mordey Victoria Alternator used as a Motor.

This test was carried out by my instructions on February 18th, 1891, four months before that witnessed by Prof. Forbes.

A 2,000-volt 25-kilowatt alternator was run as a motor, driven by a 37·5-kilowatt generator. The motor drove a dynamo which was loaded until the alternator motor was taking about its full normal current, it being assumed that this represented full power. Separate tests* have proved this assumption to be justified. The following readings were taken with a resistance of straight platinoid wire between the machines:—

Test A.

Volts. Generator terminals.	Volts. Motor terminals.	Ampères.	Resistance in line. Ohms.
2,340	2,002	13·74	32
2,358	1,932	13·	48

The volts of the generator were raised above the motor volts sufficient to supply approximately the line loss.

This test was quite satisfactory, and, of course, settled, so far as we were concerned, any question that might at any time arise as to power transmission over long lines by synchronous motors—a matter that was from time to time coming up in connection with proposed installations. As a result I always considered it quite safe to quote for work up to a line loss of 20 per cent. But, my attention being recalled to the subject by the extraordinary statements of Prof. Forbes, I took the opportunity, after writing the foregoing explanation, to make some tests having a particular bearing on the details of the question before us. In some respects they are rather wanting in completeness—I was not always able to carry them as far as I wished—but I feel sure that you will approve of my supplementing my explanation by an account of such tests as the facilities at my disposal at the moment rendered possible.

Tests of 50-Kilowatt Alternator as a Motor.

The object of these tests was to ascertain the effect of inserting resistance between two alternators, one of which ran without load as a synchronous motor.

It was desired to find—

(*a*) What resistance was required to cause the motor to fall out of step;

(*b*) How much the current varied; and

(*c*) Whether any "hunting," or pulsation, was set up.

Two similar 2,000-volt 50-kilowatt alternators were used.

Generator.—This was driven by a separate engine capable of working it up to full load. It was run without governor, and controlled by hand at the throttle valve.

Motor.—This was started and brought up to synchronism by a small direct-current motor, driving by a belt which was thrown off as soon as the large motor was running synchronously.

The two machines were excited from a separate dynamo, their fields being in parallel.

The E.M.F. at the generator terminals was measured, and the current from armature to armature. The field currents were not measured, nor the E.M.F. at the motor terminals.

The generator was excited to give 2,000 volts, and then the motor field was adjusted till the current received by the armature was a minimum. This will be understood from fig. 2, which is reproduced from a paper I had the honour of reading before this Institution last year.†

It may be remembered that I showed that there is a well marked excitation that reduces the armature current to a minimum for any given load, and therefore gives a maximum power-factor and maximum

* *Journal*, xxii., 127.

† "On Testing and Working Alternators," *Journal*, xxii., p. 128, February 23, 1893.

efficiency. If the excitation be varied on either side of that value, the armature current taken by the motor rapidly increases.

In working a motor it is desirable always to adjust the excitation till the bottom of this V curve is reached—that is to say, until the armature current is a minimum. In the case before us this current was found to be 1·6 ampéres. Having got this, the excitation was not disturbed, and the following readings were taken :—

Test B.

Volts at generator terminals.	Current.	Resistance in external circuit between generator and motor.	Remarks.
2,000	1·6	0	Current steady.
"	1·6	10	"
"	1·6	20	"
"	1·7	35	"
"	3·5	63	"
"	3·6	69	Current rather unsteady.
"	5·3	77	"
"	—	90	Current increased rapidly at this point, and the motor slipped quietly ont of step.

In the first place, it is to be noted that there was no "hunting," or pulsation. The unsteadiness of the current was not regular.

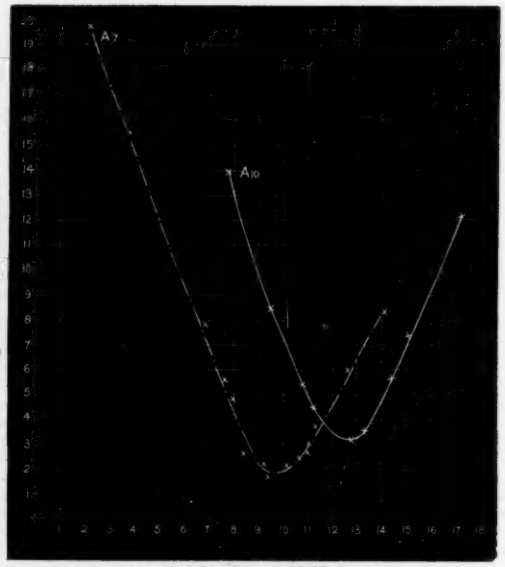


Fig. 2.

Examining this test with a view to its practical aspects, it will be seen that it fully supports the explanation given at the commencement.

(*To be continued.*)

Physical Society, February 23rd, 1894.

Prof. A. W. Rucker, M.A., F.R.S., President, in the chair.

Mr. J. W. Kearton was elected a member of the society.

A Note on a New Electrical Theorem was read by Mr. T. H. Blakesley, M.A., M.Inst.C.E.

Two or more dispositions of electromotive forces in any network of conductors, which produce at every part of the network the same currents are defined as *equivalent systems*. The following theorem is then stated and proved: in any system of conductors possessing seats of electromotive forces at any number of points, if any of these sources be moved along the various bars of the conducting system, and where a point of junction is encountered, each becoming a seat of the *same* electromotive force in *each* of the newly encountered bars, then the disposition at any moment is equivalent to that at any other moment, and, therefore, to the original disposition. Equivalent systems might also be defined as being such as produce equal expenditure of power in each part. From the above theorem the following propositions are deduced by the author: 1. That if any closed surface contains a portion of a network, then an electromotive force in any bar cutting the surface can be replaced by equal electromotive forces (in opposite directions as regards the surface) in all the other bars cutting the surface, without disturbing the current in any part of the network. 2. If two systems of electromotive forces be equivalent, one may be derived from the other.

NOTES ON DESIGNING A SYSTEM OF UNDERGROUND ELECTRIC LIGHT MAINS.*

By JOHN H. RIDER.

The importance of a satisfactory system of underground mains in a scheme for town lighting may be estimated, when we consider that in generating the electricity we have only done half the work.

We have still to convey it to the consumers, and in many cases this means to distribute it over a wide area.

The difficulties met with in so doing have given rise to the various systems of "high and low tension," and of "continuous and alternating currents," which have been so much discussed by electrical engineers.

It is not my intention, however, to dwell on these points, but rather to offer some observations on underground mains generally.

At whatever pressure we may generate our electricity, we are compelled by law to deliver it to our customers at a low pressure. In the case of a general low pressure system, this is done by means of a distributing network, fed at various points by feeder cables.

When the generation is at high pressure, we may use either a low pressure distributing network, fed through transformers at various points, or we may place transformers on the consumers' premises, and so have practically no low pressure network at all.

The Board of Trade, however, will now only give its sanction for this latter course on the distinct understanding that, when called upon to do so by them, a low pressure distributing main will be laid down, and the house transformers removed.

Therefore all arrangements using house transformers can only be looked upon as of a temporary nature.

At the outset we should make a radical distinction between "distributing mains" and "feeders."

"Distributing mains" are those from which the services to the houses are taken. It is therefore necessary to have them of such a cross section, that the fall in pressure from any feeding point to the farthest service on that section, does not exceed, say, 2 per cent. when all the lamps are burning.

Then if we keep the various feeding points at a uniform pressure, we may be certain that the whole of the distributing network has a voltage within 2 per cent. of this.

In the case of an ordinary business street, it will be found necessary to have the feeding points at not greater than about 250 yards apart, in order to have the distributing mains of a reasonable size.

"Feeders" are mains going direct from the station to the various feeding points, and their use is to feed the distributing network through transformers or otherwise.

While we may take more than one feeder to any feeding centre, yet in no case should we arrange any one feeder to supply more than one feeding centre. We should find it impossible to keep the voltage constant all over our distributing network if we did so.

The pressure at the feeding centres must be kept constant by raising the pressure of the several feeders at the station, in proportion to the current flowing through them. As it is impossible to say that the demand for current will always be equal all over the network, it will be necessary to regulate each feeder independently of the others. On direct current systems this means raising the pressure of the dynamos when the load comes on, and, when the feeders are supplied from omnibus bars, having a regulating resistance in each feeder.

On alternating current systems the pressure of the machines need not be altered, as the necessary voltage may be added to the feeders by means of adjustable transformers in series with them.

The most satisfactory method of indicating at the station the voltage at the different feeding centres, is to run back pilot wires from each, and to connect them to voltmeters on the switchboard. The attendant has then simply to regulate for constant volts, and the current in each feeder will take care of itself.

In all cases the pilot wires should be connected to the low pressure network, and not to the high pressure side of the transformers, as has been done in some alternating current stations.

As the feeders in many cases will be long, we must allow a much greater fall of pressure in them at full load than in the distributing mains. It no longer becomes necessary to keep an approximately even pressure over their whole length, as we do not take service wires from them. In many low pressure systems a drop of from 10 per cent. to 20 per cent. at full load is allowed, and this of course has to be met at the station by an equal increase, in order to keep the pressure constant at the feeding centres. If we use larger feeders we shall have less drop, and if smaller, then greater drop.

Lord Kelvin's rule is generally quoted in this case, viz.: that the maximum economy is obtained when the annual interest on the cost of the feeders equals the annual cost of the energy wasted in them. But it must not be forgotten that small feeders and a large loss also mean larger plant, in consequence of the increased pressure required. This will go to make the cost of the wasted energy higher.

We may divide the many systems of laying mains into two chief classes, "drawn in" and "built in." By the former I mean those which are drawn into pipes or conduits, and by the latter those which are either laid direct in the ground, such as armoured cables, or run in solid with bitumen, &c., such as Callender's solid system. Each class has its advantages and disadvantages, which are, however, much modified when applied to both feeders and distributing mains.

The chief advantages of a "drawn in" system are :—

(1.) Easy to inspect.
(2.) Easy to add cables.
(3.) Easy to withdraw cables.

As a "drawn in" system generally requires more inspection than

* Paper read before the Northern Society of Electrical Engineers, March 12th, 1894.

a "built in" one, it provides its own remedy. In order that cables may be easily added, it is essential that the conduit should be made large enough, or that spare pipes should be provided. This tends to increase the prime cost.

When a "drawn in" system is used for the distributing mains, and service branches are taken off, it becomes impossible to remove the cables without first disconnecting all the consumers. For feeders, however, as no branches are taken off, this is no drawback.

The "built in" systems have the advantages of:—

(1.) Generally requiring less space.
(2.) Being easier to lay.
(3.) No danger from gas or water.
(4.) Less prime cost.

Their chief disadvantage lies in our being unable to increase them without re-opening the streets.

For low pressure distributing mains this disadvantage need not be one at all, for if these mains be calculated with reasonable care for the requirements of the district, they should rarely require enlarging. And if at some future time a greater demand comes at one point than the cables can carry, the simplest way is to run another feeder to that point, and to leave the low pressure network as it was.

This of course means that the feeders should be laid on a "drawn in" system.

I venture to think that a combined system of "drawn in" for the feeders, and "built in" for the distributing mains, offers a number of advantages.

The distributing mains should only require extending in order to light new streets, and opening the ground may be therefore allowed. But new feeders have in many cases to be taken through streets already lighted, in order to reach the new districts, and so they should be "drawn in" to avoid opening the same streets a second time. Opening the streets is such a nuisance to everybody, besides being very expensive, that this point is well worth consideration.

Judging from recent experiences, a considerable difficulty in connection with a "drawn in" system, is the danger from gas explosions. There can be little doubt that the gas comes from leaky or broken gas pipes in the vicinity of the conduit. It is useless to look to the gas companies to lay their mains so that leakage would become impossible. An unlooked for subsidence of the soil may cause a drawn joint or a broken pipe, and it then only requires a spark to complete the mischief. A thorough ventilation of all electric pipes, conduits, and manholes, together with great care in the laying and subsequent inspection, seems the only way to minimise the risks.

The perfect freedom of an armoured cable system, laid direct in the ground, from such accidents, is without doubt, a very strong point in their favour.

In most "drawn in," and in some "built in" systems, it is necessary to either make service boxes opposite the houses as the cables are laid, or else to build such boxes with iron pavement covers when required. Both are expensive methods. But with an armoured cable we need make no preparation for future service connections. Each case is dealt with as it arises, and by the use of a small split junction box of cast-iron, placed around the cable and afterwards filled up with insulating material, the joints can be well and cheaply made.

So far what has been said will apply with equal force to either continuous or alternating current systems. But alternating current mains require special precautions to be taken in their design, which need not be considered at all in the case of those for continuous currents.

Any current of an alternating or varying character, flowing in any conductor will set up electromotive forces in neighbouring conductors, and as a result of these electromotive forces, currents will flow, depending in strength upon the resistances encountered.

It is most essential that adjacent wires should be protected from such currents, and the remedy that suggests itself is to entirely surround the alternating current conductors by a metallic sheathing, such as an iron or a lead covering.

This, however, would only remove the disturbances from the neighbouring wires to the sheathing itself. It would not prevent them altogether, but may in fact increase them, and so cause a great waste of energy.

To stop them, it would become necessary to place both the flow and return conductors within the same pipe or sheathing, and if the system were a three-wire one, then all three wires must be so treated. A perfect cure is only obtained when the conductors are so placed with respect to the pipe or sheathing, that their centres are practically coincident. A concentric cable meets this condition, either when drawn into an iron pipe, or when lead covered and armoured.

I believe many alternating current systems are working where this precaution is more or less disregarded, and the amount of power lost through waste currents is unknown. Considering that these losses are going on all the time the station is running, they must amount to a good deal in the course of a year, and in some cases may probably equal the magnetising current losses of the transformers.

It would appear that this question is either not understood, or else ignored, by many who have to design alternating current mains. In a recent case it was specified by a well-known engineer, that three separate lead covered cables were to be used, for a three-wire alternating system. In the scheme which I am at present carrying out, the actual arrangement for the low-tension mains was left open, so that every contractor might tender on his own lines, and for his own system. It was distinctly pointed out that alternating currents were to be used, on the three-wire system, and yet out of 20 different offers, no less than nine had entirely overlooked the question of induced currents.

Some firms proposed to use separate lead covered cables, drawn into cast-iron pipes. Others offered separate lead covered and armoured cables, to be laid direct in the ground. Others again proposed to use two concentric armoured cabcs, the middle wire of the system being divided and placed half in each cable. Of course, when the loads on the two sides of the system were such that no current flowed in the middle wire, each cable would act just as a single sheathed cable.

These proposals came from firms of the highest standing in the cable trade, and would show that there are many persons who have not yet fully grasped the importance of preventing waste currents.

As I said before, the three conductors must be under exactly the same conditions, and within the same pipe or sheathing, to entirely do away with the difficulty, and a triple concentric armoured cable meets the case perfectly.

But when a triple concentric cable is used as a distributing main, the question of service joints comes in, and it is not the easiest matter in the world to make a good branch joint on such a cable. Not only are the branches to be pieced in, but the cable itself must be left continuous.

The low-tension cable we have adopted in Bolton is made by Messrs. Siemens Bros. & Co., Limited, and consists of three separately insulated conductors twisted up together into one cable, and then lead sheathed and iron armoured. The effect of the twisting is to make the three conductors have practically the same centre. The making of service joints is much simpler than with a triple concentric cable, as when the sheathings are cut through, each conductor becomes accessible, and can be treated as desired.

With reference to a three-wire system, it is often stated that when the load is equal on each side, no current flows in the middle wire. But although this is often true, it is not necessarily so, as it altogether depends whereon the particular main the lamps are taken off.

Suppose we have a three-wire main going out from a station or supply centre, and that close to the station 100 lamps are taken off on one side. At 150 yards away let another 100 lamps be taken off, but from the other side. Then our meters in the station would show equal current in the two outer mains, and we might assume that none was flowing in the middle wire. But for 150 yards of its length it would be carrying a current equal to either of the outer cables.

This, of course, is an exaggerated case, but it will show that it depends upon the positions, as well as upon the numbers of the lamps, how much current flows in the middle conductor.

A point of great interest in connection with an alternating current scheme is, that although the low pressure distributing network may be laid on the three-wire system, yet it is only necessary to have two-wire feeders. The transformers must be made with three terminals on the secondary coils, and the primary current will then adjust itself to the mean of the loads on the two sides of the secondary.

If the transformers be designed so that there is only a 2 per cent. total variation in pressure from no load to full load, then the difference in voltage on the two sides of the system can never be more than 1 per cent., even in the almost impossible event of full load being on one side, and none on the other. In such a case the primary would take a current equal to half full load.

This is of great practical importance, as the station machinery and switchboards can be arranged for a simple two-wire system, while all the advantages of a three-wire distribution are retained.

At all the principal points of inter-connection in the distributing network, junction boxes should be placed, so arranged that the various sections may be easily connected or disconnected for the purposes of testing, repairs, &c. Soldered joints would be here out of the question, so the cable ends should be sweated into thimbles, which may be clamped together, or to properly arranged connecting bars, as desired. If the insulating material be other than rubber, then the boxes may be filled up with oil to keep out the damp. The oil could be pumped out in a few minutes, when it was necessary to make a disconnection.

A very important point in connection with an underground system of mains, is the question of insulation resistance. I am inclined to think that a great deal too much is often made of shop tests on the cable, and far too little of tests when the cables are laid and all joints made. We may think because the cables give an insulation resistance of so many thousand megohms per mile, after 24 hours immersion in water, that we are certain of an excellent system. Such tests and results are most excellent in their way, but what insulation resistance is obtained when the cables are laid? A badly insulated joint has a wonderful effect in producing bad results and is practically equal to a faulty place in the cable. Therefore all joints should be most carefully watched while making, and a guarantee obtained from the contractor, rather of an insulation resistance when the cables are laid complete, than when individual coils are tested in a tank of water.

Besides testing for insulation in the ordinary way, all cables should be tested for breaking down, with a voltage at least twice the ordinary working pressure.

Conductors of bare copper should only be used for continuous currents of low tension, as if used for alternating currents it is practically impossible to lay them so as to avoid induction effects. They have been used by Crompton for continuous currents up to about 200 volts with considerable success, but on his system the conductors are tightly strained, and are supported on properly shaped insulators. In some cases bare strip has been laid in culverts, and carried upon porcelain bridge pieces, which can only by courtesy be called insulators. Little or no attempt appears to have been made to prevent surface leakage on the supports, with the result that the insulation resistance of such mains is often a minus quantity. The liability of all such systems to stoppage from water flooding, and the large sizes of the conduits required, are points against their use. Their only recommendation appears to be in the question of prime cost.

A properly constructed and properly ventilated subway system under our streets, would much simplify the question of laying electric mains. But the dangers arising from gas and water pipes bursting, to say nothing of the enormous cost, stand in the way of its adoption.

NEW PATENTS—1894.

4,055. "Improved telephone exchange system." P. E. E. Ravebot and G. A. Hess. (Date applied for under Patents, &c., Act, 1883, Sec. 103, August 8th, 1893, being date of application in France.) Dated February 26th.

4,083 "Improvements in electric arc lamps." K. Schleyder. Dated February 26th. (*Complete.*)

4,091. "Appliances for the carbons of electric arc lamps for increasing the duration thereof." F. Jehl and M. von Hardtmuth. Dated February 26th. (*Complete.*)

4,096. "Improvements in cable traction operated by electricity as a motive power." J. L. Copping. Dated February 26th.

4,102. "Improvements in street fire alarms and telephonic combinations for same." H. A. C. Saunders and A. C. Brown. Dated February 26th.

4,113. "Improvements in electric batteries." H. T. Barnett. Dated February 27th.

4,142. "Improvements in construction of electrical letters and signs." A. R. Upward. Dated February 27th.

4,144. "Improvements in electrodes for arc lamps." E. O. Clark. Dated February 27th. (*Complete.*)

4,168. "Improved construction of electric battery." A. W. Hussey. Dated February 27th.

4,170. "Improvements in alternating current electric motors." W. P. Thompson. (Communicated by C. S. Bradley, United States.) Dated February 27th.

4,171. "Improvements in alternating current electric motors." W. P. Thompson. (Communicated by C. S. Bradley, United States.) Dated February 27th.

4,177. "A new or improved reel device for fire hose, electric cables, suspending cords, and the like." W. P. Thompson. (Communicated by P. Schneider, Germany.) Dated February 27th.

4,182. "Improvements in overhead electric travelling cranes." L. Higginbottom, T. Mannock, and E. Hopkinson. Dated February 27th.

4,190. "Improvements in apparatus for use with electrically illuminated signs or advertisements, or in other cases where frequent changes of electric circuits are to be made." E. L. Berry and F. Harrison. Dated February 27th.

4,197. "Improvements in or connected with bases and covers for electric switches and fuses." F. W. Busch. Dated February 27th. (*Complete.*)

4,214. "Improvements in or in connection with electricity and other meters." W. L. Spence. Dated February 28th.

4,226. "Improvements in electric arc lamps." R. H. Jahr and C. F. Schoeller. Dated February 28th.

4,231. "Improvements in steam turbines." D. Cook. Dated February 28th.

4,235. "A new electric fitting for piano." J. W. Ewart. Dated February 28th.

4,244. "Improvements in and relating to the overhead system of electric tramways." A. Dickinson. Dated February 28th. (*Complete.*)

4,254. "Improvements in electric arc lamps." J. C. B. Andrews. Dated February 28th.

4,325. "Improvements in the electro-deposition of aluminium." A. H. Harris. Dated March 1st.

4,326. "Lamp, answering the purpose for cap and loop lamp (for incandescent lamps)." T. Bamber and O. Bamber. Dated March 1st.

4,333. "Improvements in and relating to apparatus for supporting and suspending electric light and other like fittings." W. H. Johnson. Dated March 1st. (*Complete.*)

4,353. "Improvements in recorders and reproducers of phonographs." A. W. Carter. Dated March 1st.

4,366. "Improvements in dynamo-electric machines." A. J. Boult. (Communicated by Compagnie de l'Industrie Electrique, Switzerland.) Dated March 1st.

4,402. "An electricity meter." H. G. Rea. Dated March 2nd.

4,426. "Improvements in or in connection with oil and gas engines." J. P. Lea. Dated March 2nd.

4,429. "Improvements in and in the manufacture of electrical switches." A. Metzger. Dated March 2nd. (*Complete.*)

4,472. "Improvement in electrolytic processes in the manufacture of chlorine alkali and derived products." T. Parker. Dated March 3rd.

4,473. "Magnetic compass, indicating true north, whatever the magnetic variation may be." W. J. Turner. Dated March 3rd.

4,477. "An improved automatic regulator for electric generators." J. Hesketh and T. Hesketh. Dated March 3rd.

4,484. "Electro-magnetic switching." G. Michaelson. Dated March 3rd.

4,485. "Correction of an electric bell." G. Michaelson. Dated March 3rd.

4,522. "Improvements in electrically operated clocks." A. J. Boult. (Communicated by H. Campiche, Switzerland.) Dated March 3rd. (*Complete.*)

4,539. "A joint for wires and electrical conductors." W. Diesel-horst and Siemens Brothers & Co., Limited. Dated March 3rd. (*Complete.*)

4,540. "Improvements in contact bars for the overhead conductors of electrical railways and tramways." Siemens Brothers & Co., Limited. (Communicated by Siemens & Halske, Germany.) Dated March 3rd.

4,554. "Improvements in telephony." C. Adams-Randall. Dated March 3rd.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1893.

4,910. "An improvement in electric switches." E. L. Joseph Dated March 7th. Consists in making the cross connecting piece on the switch piece of comparatively thin sheet metal, turned or folded, and preferably split at the ends, so as to be more or less flexible, in order that such ends may yield more or less when pressed between the contact surfaces of the contact plates. 1 claim.

4,911. "An improvement in contact makers for electric lamp-holders." E. L. Joseph. Dated March 7th. The object of the improvement is to so construct and arrange the tongue or spring of the contact maker, that when pressed against the conductor it shall rub against the same, and thereby cause the removal from the surfaces of any dirt or other substance that would prevent their electrical contact. 1 claim.

4,912. "Improvements in the construction of spring buffer connections for the holders of electric lamps." E. L. Joseph. Dated March 7th. Claim:—The improved spring buffer connection for electric lamps, which consists of a contact piece, provided with means for the clamping thereto of the conducting wire, and the spring contact buffer case, having a screwed stud or stem, adapted to screw into a threaded hole in the earthenware or other insulating stand, and to thereby secure itself together with the contact piece in position on the said stand, substantially as described and illustrated in the drawings.

7,848. "A new or improved code for indicating telegraphic messages." J. Levi. Dated April 18th. Consists in the use of a key or system of notation, based upon the use of consonants as the indicating letters of such signal, and in making up the message to be transmitted, vowels are added to the consonants to form words, and the words being transmitted as usual telegraphically, are understood by the receiver, and upon turning to the key and following the consonants in succession as they appear in the words transmitted, the message is fully understood. 1 claim.

9,296. "Improvements in apparatus for the electrolysis of salt." T. Craney. Dated May 9th. Relates to new and useful improvements in apparatus for the manufacture of caustic soda by electrolytic decomposition of chloride of sodium or common salt, and the main object of the invention is to adapt the apparatus for continuous work to facilitate the collection of the products, and to control its operation. 4 claims.

9,302. "Improvements in contacts for electric railways." W. Q. Prewitt. Dated May 9th. Consists in providing a detachable trolley carrying apparatus. 4 claims.

9,821. "Improvements in galvanometers." H. H. Lake. (Communicated from abroad by Whitney Electrical Instrument Company, of America.) Dated May 16th. In order to control or regulate the relative effect of the current and of the field magnet on the needle, a solenoid is provided with a core and means to adjust its position in said coil, so as to vary the effect produced on the needle by the current passing through the coil. Another feature of the invention consists in making the end of the said core diagonal to the axis of the solenoid. 7 claims.

9,965. "Improvements in or connected with the working and welding of metals by electricity." A. Longsdon. (A communication from abroad by the firm of F. Krupp, of Essen.) Dated May 18th. Claim:—In the working and welding of metals by electricity, the combination of two sources of current supply, one of which serves to energise the magnetic field of that source, the effective current of which is employed for heating and welding, and substantially as set forth.

11,099. "Improvements in electric glow lamps." H. H. Lake. (Communicated from abroad by E. A. Colby, of America.) Dated June 6th. This lamp, instead of having the ordinary glass receiver with leading-in wires connected to a filament, and hence employing a current of electricity directly led to said filament, has no leading-in wires whatever, and has its filament disposed in the form of a closed ring or rings suitably supported within a receiver of corresponding annular form. This filament is caused to glow through the lamp being placed in the varying field of force due to an alternating, pulsating, or intermittent electrical current, so that it is an induced current which acts upon the filament. 2 claims.

11,369. "An improved electric insulating compound and process of preparing same." A. Gentzsch, J. Goldschmidt, and E. R. von Scanavi. Dated June 9th. Claims:—1. The process of producing a vulcanisable shellac which consists in distilling shellac under a gradually increasing temperature, substantially as described. 2. In the production of a vulcanisable shellac as described in the foregoing claim, the addition to the shellac under treatment of suitable carburetted hydrogens, such as aniline oil or anthracene, substantially as described. 3. The improved insulating compound substantially as described.

11,578. "A new or improved method of electrically welding metals." W. P. Thompson. (A communication by C. L. Coffin, of America.) Dated June 13th. Claim:—The process of electric welding, which consists in electrically heating a short section of material, heating the extremities of the articles to be welded by pressing the ends of the same against the short heated section, and then completing the weld.

11,609. "Improvements in electric switches." J. F. McElroy. Dated June 13th. The object of the invention is to provide an electric switch particularly adapted for use in mechanism for heating with electricity cars propelled by electricity. 10 claims.